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Comparative analysis of animal manure substrates and decomposers on composting efficiency and nutrient profile of agricultural waste at Cagayan State University, Philippines

Gerald L. Seridon, Maurine P. Bayubay, Jake P. Abedes, Mauricio P. Bayubay, Rhea L. Trinidad*

Cagayan State University, Philippines

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ABSTRACT

The effect of different animal manure substrates and decomposers on the decomposition rate and chemical components of compost produced using agricultural waste at the Integrated Farm of Cagayan State University, Philippines from August to November 2023. The experimental study was laid out in a completely randomized design-split plot with three replications. The results showed that in the case of poultry and goat dung substrates, breakdown was far higher compared to cattle manure. *Trichoderma harzianum* and African night crawlers in combination significantly accelerated breakdown. However, there was no interaction effect between decomposers and the types of manure. While nitrogen and phosphorus levels in the compost were not much altered by manure substrates or decomposers, both cattle and poultry manure substrates greatly influenced potassium levels in the compost.

***Corresponding author:** Rhea L. Trinidad ✉ michaeluy95@yahoo.com

INTRODUCTION

Sustainable agriculture is an important component in soil fertility restoration and scaling up crop production at low risk to the environment. also composting, as it is also an exceptionally critical portion of organic cropping system(s) as it's a biomechanically active process of decomposing organic waste into beneficial soil amendments. The effectiveness of the compost depends on the decomposing agents as well as the organic waste used as substrates. Here, employing animal manure, agricultural residues, and efficient decomposers can drastically change the quality and composition of nutrients in compost (Institute for Local Self-Reliance [ILSR], 2016).

Decomposition fossils are also accountable for the decomposition of organic material. *Trichoderma harzianum*, a fungus, stimulates decomposition and enhances nutrient availability. The African night crawler (*Eudrilus eugeniae*), an earthworm, is widely used in vermicomposting to improve the quality of compost by stimulating microbial activity and nutrient content. The synergistic interaction of both decomposers can provide synergistic advantages, resulting in increased decomposition rate and nutrient content of resulting compost (Mapile and Obusan, 2021).

This study can address different Sustainable Development Goals (SDGs) of Philippine agriculture, namely SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production). Through telling how effective use of animal manure and agro-industrial waste can be through composting, this paper advocates sustainable agricultural practices that will improve soil fertility and crop productivity (ILSR, 2016).

The potential significance of this research is in the possibility of improving waste management, reducing dependency on chemical fertilizers, and offering a more sustainable agricultural system is aimed at by this research. This study intends to contribute to the achievement of local farmers through the improvement of compost quality in a good way under sustainable practices methods toward enhanced food security and resourceful utilization (ILSR, 2016).

This study aimed to evaluate the effects of different animal manure substrates and various decomposers on the decomposition rate and chemical components of compost produced using agricultural waste at Cagayan State University – Piat Campus.

MATERIALS AND METHODS

Securing of decomposers

Compost activator (*Trichoderma harzianum*) was requested at Department of Agriculture, Regional Crop Protection unit while African night crawler was purchased from Tuao, Cagayan, Philippines. Request and procurement were made two days before the set-up of the experimentation.

Experimental design and procedures

The Split-Plot in Completely Randomized Design (CRD) was used. Main plot represents the different animal manure substrates were used in the experiment while sub-plots were the various decomposers. The study was replicated three (3) times.

Preparation of the Substrate

Collected and chopped the organic substrate using the mechanical shredder into smaller pieces to enhance surface area for microbial action.

Preparation of beds

Compost beds were prepared by piling manure and alternately arranged with 50% rice straw, 10% of oyster mushroom spent and 10% vegetable waste (including cut/uprooted waste and weeds/grasses). Plot size of 1 meter by 2 meters was observed. Piling was done through the alternate arrangement of the substrates, totaling 100 kilograms with wooden plank in between to avoid the moving of worm from one place to another.

Pre-decomposed process

After the preparation of beds, piled materials were pre-decomposed at least two weeks. This was done to

set the environment for the introduction of African night crawler and considerable amount of heat will be removed from the raw materials.

Application of compost fungus activator

Compost Fungus Activator (*Trichoderma harzianum*) obtained from Department of Agriculture- Cagayan Valley Integrated Agricultural Laboratory (DA-CVIAL) was diluted in water following the protocol stipulated in the manual.

The frequency of application was observed based on the procedures. Application of *Trichoderma harzianum* was only observed in B2 and B3 sub-plots.

Introduction of african night crawler (ANC)

African night crawler was introduced 2 weeks after piling.

The amount of ANC was based on the total amount of the substrates in each designated compost bed. One (1) kilogram of ANC was introduced for every 100 kilograms of substrates and the introduction of ANC was observed only on the B1 and B3 sub-plots.

Watering

Compost beds were sprinkled with tap water as the need arises. Equal amount of water applied per plot for uniformity.

Harvesting

Compost was harvested when all the materials in the bed were fully decomposed. This was done by observing the finish product smell like earth or soil, dark brown to black color and crumbly texture. Harvesting was done early in the morning and air dried in a vermicast chamber for three days prior to product bagging.

Submission of Samples for pH and nutrient analysis

Compost samples collected in each sub-plots were air dried for at least three days prior to submission for analysis at the Cagayan Valley Integrated Agricultural Laboratory (CVIAL).

The air-dried composts were sieved, weighed, and properly labeled to avoid inter-mixing of materials during laboratory analysis. One (1) kilo per sample material was submitted for analysis.

Data gathered

Statistical tool

The data was analyzed using the Statistical Tool for Agricultural Research (STAR). Analysis of Variance (ANOVA) using the Least Significant Difference Test (LSD) at 5% and 1% levels of significance were used to compare the significant difference of all treatments tested.

RESULTS AND DISCUSSION

Number of days to decompose

Poultry manure and goat manure substrates influence decomposition rate considerably, with decomposition times of 47 days and 49 days, respectively, compared to 53 days for cattle manure substrate.

Table 1. The treatment combinations were as follows.

Main Plot (Animal Manure Substrates)	Sub-Plot (Decomposers)
A_1 - 30% Cattle Manure + 50% Rice straw + 10% Oyster Mushroom Spent + 10% Vegetable Waste	**B_1**- African Night crawler
A_2 - 30% Poultry Manure + 50% Rice straw + 10% Oyster Mushroom Spent + 10% Vegetable Waste	**B_2**- Trichoderma harzianum
A_3 - 30% Goat Manure + 50% Rice straw + 10% Oyster Mushroom Spent + 10% Vegetable Waste	**B_3**- Combination of Trichoderma harzianum and African night crawler

In most cases, goat manure substrate and poultry manure substrate decompose faster compared to cattle manure substrate, an aspect that can be explained by their differences in chemical

composition and physical texture. This is against the assertion by Hassan and Islam (2017) that poultry manure is high in nitrogen content and has a higher concentration of nutrients, hence enhancing quicker microbial action. In addition, the smaller particle size of poultry manure allows for more exposure of surface area, which supports a faster breakdown process. Goat manure, which is more fibrous and of lower carbon-to-nitrogen ratio, favors quicker microbial colonization, according to Sinha and Shukla (2019). In contrast, cattle manure is rich in lignin and particle size, which tends to retard the decomposing processes. All these taken together favor a better environment for microbial activity in poultry and goat manure compared to cattle manure. Table 2 shows the number of days taken by various animal manure substrates to decompose using different decomposers. The effect of the differences in decomposers, as the independent variable, had a significant effect on the rate of decomposition.

Table 2. Number of days to decompose different agricultural wastes as affected by different animal manure substrate and different decomposers.

Sub-Plot (Decomposers)	Main Plot (Animal Manure Substrate)			Sub-plot Means
	A1 – Cattle Manure Substrate	A2 – Poultry Manure Substrate	A3 – Goat Manure Substrate	
B1- African Night Crawler (ANC)	54	46	49	50[a]
B2- *Trichoderma harzianum*	56	48	51	52[a]
B3- Combination of ANC and *Trichoderma harzianum*	48	45	47	47[b]
Main-Plot Means	53[a]	47[b]	49[b]	
C.V.		4.67%		4.72%

**Means with the same letter are not significantly different.

African Night crawler combined with *Trichoderma harzianum* had a quicker decomposition time of 47 days compared to *Trichoderma harzianum* alone at 52 days and African Night crawler alone at 50 days. As stated by Ndegwa and Thompson (2000), African Night crawlers ensure rapid decomposition of the organic matter by providing aeration and substrate enrichment with nutrient-rich casts, which then enhances microbial activity. Combination with *Trichoderma harzianum*, the interactive effect further accelerates the rate of decomposition based on enhanced activity of enzymes as well as maximized availability of nutrients (Gomez *et al.*, 2015).

This conclusion is consistent with that by Mokhtar *et al.* (2018), which showed that the combination of *Trichoderma harzianum* and African Night crawler provides both a shorter composting period and better quality of compost than individual contributions by the individual components.

Table 3. pH level of compost as affected by different animal manure substrates and different decomposers.

Sub-Plot (Decomposers)	Main Plot (Animal Manure Substrate)			Sub-plot Means
	A1 – Cattle Manure Substrate	A2 – Poultry Manure Substrate	A3 – Goat Manure Substrate	
B1- African Night Crawler (ANC)	6.88	6.98	6.87	6.91
B2- *Trichoderma harzianum*	6.77	7.21	6.83	6.94
B3- Combination of ANC and *Trichoderma harzianum*	6.92	7.01	6.65	6.86
Main-Plot Means	6.86	7.07	6.78	ns
C.V.		5.46%		5.38%

**n.s.- not significant.

The interaction effects between varied animal manure substrate (as to the main plot) and varied decomposers (as to the sub-plot), revealed no significant interaction effect between the two as mentioned. This indicates that the performance of each decomposer was the same in all the varied manure substrates. The main effect of the various factors was significant individually, showing that although manure type and decomposers both affect the rate of decomposition, their interaction did not yield compounded effects.

pH Level of Compost

Table 3 presents the pH level of the compost as affected by different animal manure substrates. Regardless of the substrate used, the pH levels obtained were close to neutral typically ranging from 6.78 to 7.07. This aligns with Hargreaves *et al.* (2008) findings that the end compost pH was between 6.5 and 7.5, which is best for agricultural use. The Fully decomposed cattle, goat, and poultry manures contributed to maintaining for its pH level, which was confirming their viability as composting materials (Zhao *et al.,* 2015).

The findings showed that the different composts attained a neutral pH using the different animal manures which is desirable as it supports the availability of nutrients and microbial activity necessary for plant growth.

Table 4. Nitrogen content (%) compost as affected by different animal manure substrate and different decomposers.

Sub-Plot (Decomposers)	Main Plot (Animal Manure Substrate)			Sub-plot Means
	A1 – Cattle Manure Substrate	A2 – Poultry Manure Substrate	A3 – Goat Manure Substrate	
B1- African Night Crawler (ANC)	0.71^{ab}	0.53^{b}	0.77^{a}	0.67
B2- *Trichoderma harzianum*	0.55^{b}	0.93^{a}	0.35^{b}	0.61
B3- Combination of ANC and *Trichoderma harzianum*	0.57b	1.09^{a}	0.43^{b}	0.66
Main-Plot Means	0.61	0.85	0.52	
C.V.		19.03%		21.03%

**Means with the same letter are not significantly different.

The data in table 3 indicated that the various decomposers slightly influenced pH, but the difference was not statistically significant. The study indicated that the use of African night crawlers and *Trichoderma harzianum* as decomposers yielded the lowest pH of 6.86. On the other hand, the use of African night crawler alone yielded a pH of 6.91, while *Trichoderma harzianum* alone yielded a pH of 6.94. This parameter highlights that the application of any of the decomposers does not adversely affect the pH level of the end compost. This was in line with the observation of He et.al. (2017) which concluded that the various organic substrates and microbial communities do not have significant interactions to affect pH levels during composting. The various animal manure substrates and various decomposers showed no significant interaction effect on the pH value of end compost in this study as well. The non-significant variation of this parameter is consistent with the findings of according to Chen *et al.* study in the year 2019 was the pH value of compost is mostly affected by the nature of the substrate and the various decomposers separately.

This is also asserted by the work of Wang *et al.* (2020) which reported that the pH levels were constant and not greatly influenced by the interaction of manure types and decomposers during the composting process.

Nitrogen Content (%)

Table 4 shows the nitrogen content of the compost as affected by different animal manure substrates. The data shows variations in nitrogen content of compost

that were derived from various animal manure substrates where poultry manure substrate yielded the highest nitrogen concentration at 0.85%. In comparison, cattle manure substrate obtained 0.61%, while goat manure substrate obtained 0.52%. Although the differences in nitrogen content among these substrates were not statistically significant, poultry manure could be more effective in enhancing nitrogen level of compost. This result support what was found by Hao *et al.* (2004), as mentioned in Zhang *et al.* (2013), that poultry manure often has richer nutrients than other livestock waste. Even though the differences were not that big, they still matter when aiming to improve compost quality and soil health.

Table 5. Phosphorus content (%) of compost as affected by different animal manure substrates and different decomposers.

Sub-Plot (Decomposers)	Main Plot (Animal Manure Substrate)			Sub-plot Means
	A1 – Cattle Manure Substrate	A2 – Poultry Manure Substrate	A3 – Goat Manure Substrate	
B1- African Night Crawler (ANC)	0.50	0.41	0.13	0.35
B2- *Trichoderma harzianum*	0.31	0.19	0.07	0.19
B3- Combination of ANC and *Trichoderma harzianum*	0.21	0.32	0.09	0.21
Main-Plot Means	0.34	0.31	0.10	ns
C.V.		117.85%		143.71%

**n.s. – not significant.

When noting in at the effect of decomposers alone, *Trichoderma harzianum* resulted in 0.61% nitrogen, African night crawlers had slightly more at 0.67%, and the combination of the two gave the highest at 0.70%. This suggests that already the mixture of both decomposers helps more in boosting nitrogen during composting. Some research says that interactions between microbes and invertebrates improve how nutrients are cycled, which makes composting more effective (Cortez *et al.*, 2018; Dung *et al.*, 2020). This can be used by farmers for better composting outcomes.

The interaction between manure types and decomposers, also shown in Table 4, indicated that poultry manure when combined with decomposers produced the best nitrogen result compared to cattle or goat manure with same decomposers. This means poultry manure likely offers a better condition for decomposers to work, which leads to higher nitrogen in the compost. Yadav *et al.* (2013) pointed out that poultry manure helps in faster nutrient breakdown when paired with ANC and *Trichoderma harzianum*. Singh *et al.* (2008) also reported that poultry manure treated with both decomposers gives better nitrogen results. The good mix of rich nitrogen and active decomposers like ANC and Trichoderma makes poultry manure more useful in compost production (Jain and Singh, 2019).

Phosphorus Content (%)

Table 5 presents the amount of phosphorus level of compost as influenced by different animal manure substrates. The phosphorus content of the compost as affected by cattle manure substrate is 0.34%, which is slightly higher than poultry manure substrate of 0.31%, and goat manure substrate of 0.10%. Different animal manure substrates as independent variables tend to show minimal variation on the phosphorus content with no significant difference observed across these substrates. This finding supports to the findings of Ghosh *et al.* (2007) that the variation in

phosphorus content among cattle, poultry, and goat manure substrate is often not statistically different after composting, as phosphorus is less mobile and less prone to loss compared to nitrogen. In the same vein, Rao (2005) pointed out that phosphorus availability in compost is largely influenced by microbial decomposition rather than the substrate type of manure, resulting in similar phosphorus results irrespective of substrate. In addition, Singh et.al. (2008) further pointed out that even though poultry and cattle manure possess slightly higher initial phosphorus content than goat manure, the ultimate content is not much different based on the phosphorus dynamics involved in composting. This result reflects that final compost as affected by various animal manure substrates was comparable in terms of phosphorus content.

In terms of different decomposers, the phosphorus content of compost is influenced by the activity of different decomposers, such as African night crawler (ANC), *Trichoderma harzianum*, and their combination. Compost treated with African night crawler alone had a phosphorus content of 0.35%, which was higher than that of the combination of ANC and *Trichoderma harzianum* (0.21%) and Trichoderma alone (0.19%). Despite these variations, the differences in phosphorus content were not statistically significant. Rao (2005) described that phosphorus is quite stable throughout composting and less prone to microbial changes than nitrogen, which could be the reason for not finding any considerable differences among the treatments. Singh et.al. (2008) also mentioned that although decomposers such as ANC and *Trichoderma harzianum* enhance organic degradation and nutrient release, their effect on phosphorus availability is restricted because phosphorus is mostly bound in organic matter less susceptible to microbial activity.

This result indicates that the different decomposers not influence the phosphorus levels in compost.

Table 6. Potassium content (%) of compost as affected by different animal manure substrate and different decomposers.

Sub-Plot (Decomposers)	Main Plot (Animal Manure Substrate)			Sub-plot Means
	A1 – Cattle Manure Substrate	A2 – Poultry Manure Substrate	A3 – Goat Manure Substrate	
B1 – African Night Crawler (ANC)	0.27	0.27	0.12	0.22
B2 – *Trichoderma harzianum*	0.27	0.24	0.11	0.21
B3 – Combination of ANC and *Trichoderma harzianum*	0.25	0.28	0.12	0.22
Main-Plot Means	0.26[a]	0.26[a]	0.12[b]	
C.V.		4.67%		4.72%

**Means with the same letter are not significantly different.

The interaction between different animal manure substrates (cattle, poultry, and goat manure) and decomposers (*Trichoderma harzianum*, African Night Crawler, and their combination) showed no significant interaction effect on the phosphorus content of compost. This indicates that the manure substrate type does not greatly impact the effectiveness of decomposers on phosphorus concentration. Notwithstanding variations in phosphorus concentration at the outset in the manures, being cattle manure at 0.34%, poultry at 0.31%, and goat manure at 0.10%, the resultant phosphorus content of the compost at the end was not greatly impacted by decomposer interaction.

Regardless of the combination of different animal manure substrates (cattle manure, poultry manure, goat manure) and different decomposers (African

night crawler, *Trichoderma harzianum*, and combination), the result showed no significant differences in phosphorus content across treatments. This outcome is consistent with the findings of Singh *et. al.* (2008) and Rao (2005), that phosphorus stability during composting reduces the likelihood of interaction effects between substrates and decomposers. Phosphorus remains in organic or mineral-bound forms, and microbial activity from earthworms or fungal decomposers does not have great impact on its final availability.

Potassium Content (%)

Table 6 shows how the potassium content of compost was influenced by the different animal manure substrates. As an independent variable, the manure types affect the potassium level, with cattle and poultry manure having both 0.26% potassium, which is higher compare to goat manure that only has 0.12%. This difference can be because of the nutrient makeup of each manure. Naturally, poultry and cattle manures have more potassium because of how the animals digest and absorb nutrients. This is also supported by Adekiya *et al.* (2020) and Ayoola and Makinde (2019), saying that compost made from cattle and poultry manure often leads to better potassium levels in soil and also better plant growth compared to goat manure. This result suggest goat manure may not give the same potassium benefits as the other two.

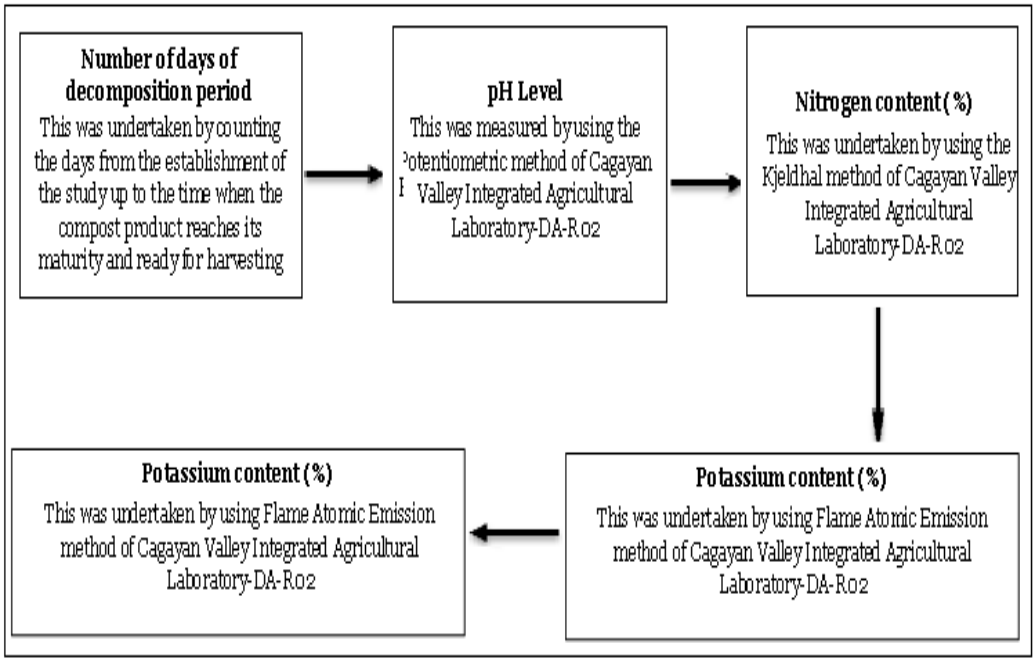

Fig. 1. Data gathering procedure of the study.

Also, the potassium content based on different decomposers. Using *Trichoderma harzianum* alone resulted in 0.21% potassium, while African night crawler alone and its combination with Trichoderma both had 0.22%. The values are close and the difference isn't significant, meaning any decomposer used doesn't really changed potassium level in the final compost. This supports the earlier studies by Aira and Dominguez (2009) and Singh *et al.* (2019), who found decomposers may help compost quality in general, but don't impact potassium much.

No interaction effect between manure and decomposers was seen for potassium content. This mean while manure type and decomposer can affect potassium separately, using them together don't lead to stronger results. One reason could be that potassium in manure is already stable, and doesn't depend much on how it's decomposed. Unlike nitrogen, potassium maybe not that sensitive to microbial action. So, even if the decomposers help in breaking down compost, they don't really change how much potassium comes out (Bortolini *et al.*, 2019).

Findings indicated that poultry and goat manures were more decomposed compared to cattle manure, particularly when blended with Trichoderma harzianum and African night crawlers, although no interaction effect was established. Compost phosphorus level and pH were not significantly influenced by decomposer or manure type. Although nitrogen level was not affected by either factor independently, there was an interaction effect showing that poultry manure with decomposers yielded higher levels of nitrogen. Potassium level was significantly influenced by manure type (especially cattle and poultry) but not by decomposers, with no interaction effect.

CONCLUSION

The research concluded that poultry and goat manures were decomposed much more rapidly compared to cattle manure, especially when integrated with *Trichoderma harzianum* and African night crawlers, but without any significant interaction effect between manure types and decomposers. Compost pH and phosphorus levels were not affected by either of these factors, but the poultry manure with decomposers had the highest nitrogen level, with a significant interaction effect. Potassium content was markedly affected by type of manure, particularly cattle and poultry but not by decomposers.

RECOMMENDATIONS

Farmers and compost manufacturers are advised to use poultry or goat manure in conjunction with *Trichoderma harzianum* and African night crawlers to ensure quicker decomposition and increased nitrogen levels in compost. Long-term impacts on soil fertility and crop yields can be investigated further to aid in the adoption of these composting methods in sustainable agriculture.

REFERENCES

Adekiya AO, Agbede TM, Aboyeji CM, Dunsin O, Simeon VT. 2020. Comparative effect of poultry manure and NPK fertilizer on soil fertility, yield, and quality of maize in a tropical environment. Journal of Soil Science and Plant Nutrition **20(1),** 123-135. https://doi.org/10.1007/s42729-020-00123-0

Aira M, Dominguez J. 2009. Microbial biomass governs enzyme activity decay during aging of worm-worked substrates through vermicomposting. Journal of Environmental Quality **38(2),** 540-546. http://doi.org/10.2134/jeq2008.0261

Allotment Garden. 2025. NPK nutritional values of animal manures & compost etc. Retrieved from https://www.allotment-garden.org/composts-fertilisers/npk-nutritional-values-animal-manures-compost/

Ayoola OT, Makinde EA. 2019. Soil fertility restoration with composts from different organic residues. Journal of Sustainable Agriculture **43(3),** 265-280. http://doi.org/10.1080/10440046.2019.1659871

Bortolini G, Da Velga M, Loss A, Lana MDC, Oliveira PA. 2019. Chemical composition of compost from cattle, poultry, and swine manure with pine and eucalyptusbark. Scientia Agricola **76(1),** 27-33. https://doi.org/10.1590/1678-992X-2017-0050.

Chen X, Zhang Y, Zhou H, Wang S. 2019. Effects of various organic wastes and microorganisms on composting process and quality. Environmental Science and Pollution Research, **26(11),** 10948-10959.

Cortez JW, Pinheiro MC, Silva GA. 2018. Microbial and invertebrate interactions in composting: implications for nutrient cycling. Applied Soil Ecology **128,** 12-20.

Dung TT, Nhan TM, Thanh HT. 2020. The role of decomposers in nutrient dynamics in composting. Waste Management **102,** 400-407.

Ghosh M, Chattopadhyay GN, Baral K. 2007. Vermicomposting of farm wastes with cow dung using African Nightcrawler (*Eudrilus eugeniae*). Journal of Environmental Health.

Gomez E, De La Rosa JA, Eguia M. 2015. Effects of earthworms and trichodermaon the degradation of organic waste. Applied Soil Ecology, **95,** 129-136.

Hao X, Zhang J, O'Halloran I. 2004. Nutrient management in animal waste: effects of manure type on nutrient release. Nutrient Cycling in Agroecosystems **68(1),** 81-91.

Hargreaves JC, Adl MS, Warman PR. 2008. A review of the use of composted municipal solid waste in agriculture. Agricultural and Food Science in Finland **17(4),** 279-290.

Hassan MA, Islam MA. 2017. Comparative evaluation of organic manures and chemical fertilizers on the growth and yield of tomato. Journal of Environmental Science and Technology **10(3),** 93-103.

He P, Zhang G, Yang J, Liu Z. 2017. "Influence of organic substrate type and microbial community on the composting process." Waste Management **59,** 99-108.

Institute for Local Self-Reliance. 2016. The benefits of composting & compost use. Retrieved from https://ilsr.org/articles/benefits-composting-compost/

Jain MS, Singh DP. 2019. Biodegration of organic waste through the synergistic use of decomposers and manures. Agricultural Research Journal.

Mapile MRF, Obusan MCM. 2021. Mineralization, biodegradation, and antagonistic activities of gut-associated bacteria and fungi of African nightcrawler, Eudrilus eugeniae (Kinberg, 1867). Science Diliman: A Journal of Pure and Applied Sciences **33(2),** 1–15. Retrieved from https://journals.upd.edu.ph/index.php/sciencediliman/article/view/7215

Mokhtar M, Ahmed K, Al-Mahmood S. 2018. The role of Eudrilus eugeniae in enhancing soil fertility and composting efficiency. African Journal of Agricultural Research **13(5),** 213-220.

Ndegwa PM, Thompson SA. 2000. Integrating composting and vermicomposting in the management of organic wastes. Wastes Management **20(7),** 715-723.

Rao NSS. 2005. "Soil Microbiology (4th ed.) Oxford & INH Publishing.

Singh RP, Chari KVR, Maruthi YA. 2019. Effect of microbial inoculants on the quality and nutrient content of compost. International Journal of Recycling of Organic Waste in Agriculture **8(3),** 243-251. https://doi.org/10.1007/s40093-019-00306-w.

Singh R, Sharma R, Tewari RK. 2008. Vermicomposting with cow dung and other animal wastes using earthworm species. Bioresource Technology Journal.

Sinh AK, Shukla A. 2019. Nutrient management in organic farming: A review. International Journal of Chemical Studies **7(4),** 362-366.

The Spruce. 2021. Using chicken manure as garden fertilizer. Retrieved from https://www.thespruce.com/chicken-manure-fertilizer-5189920

University of Massachusetts Amherst. 2025. Manure: New England vegetable management guide. Retrieved from https://nevegetable.org/cultural-practices/manure

Wang X, Li L, Zhang Y, Xu Y. 2020. Assessment of composting with different manure types and microbial agents: Effects on pH and Nutrient Profiles. Journal of Cleaner Production, 257, 120550.

Yadav A, Gupta R, Garg VK. 2013. Organic manure and composting: Types and practices. Springer Handbook of Soil Science.

Zhang Y, Huang Y, Chen H. 2013. Comparison of composting processes and characteristics of different manures. Waste Management **33(4),** 853-859.

Zhao Y, Xie W, Huang H. 2015. Effects of composting on the chemical properties of livestock manure. Waste Management **45,** 252-259.