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Cow dung Vermicomposting: A Comparative Study on Physicochemistry and Biodegradability of *Eudrilus eugeniae* and *Lumbricus rubellus*

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ABSTRACT: A comparative study on the vermicomposting ability and efficacy of two earthworm species (*Eudrilus eugeniae* and *Lumbricus rubellus*) on cow dung was carried out using standard methods. Data collected showed that there was an increase in the major nutrients content such as nitrogen, potassium and phosphorus as well as the electrical conductivity regardless of the vermibeds or treatment while there was a decrease in the total organic carbon, organic matter regardless of the vermibeds or treatment except the vermibed with cowdung only. The lignin content also decreased across all the vermibeds except the one with cowdung and *L. rubellus*. Vermicompost of cowdung + *L. rubellus* had highest concentrations of nitrogen (4.47±0.38) and phosphorus (114.64±0.648), cowdung +*Eudrilus eugeniae* had the highest potassium (26.7±0.849) while cowdung +dry grass+ *Eudrilus eugeniae* had the highest organic matter (33.15±0.919) and lignin (19.78±0.396) and cowdung only had the highest organic carbon. The result of the environmental parameters carried out showed that the cowdung+dry grass + *E. eugeniae* had the highest moisture (80.1±0.141), cowdung +dry grass+ *L. rubellus* had highest pH while cowdung+dry grass+*E. eugeniae* had the highest temperature (30.1±0.283). *E. eugeniae* showed a better decomposition rate with percentage decomposition of 79.90% while *L. rubellus* has 74.27%. However, there were significant differences ($p<0.05$) among the vemi-beds. In conclusion, the two species of earthworm *L. rubellus* and *E. eugeniae* are efficient in producing good nutrient quality vermicompost and are recommended for use in vermicomposting.

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The rising challenges posed by solid waste production, particularly the burgeoning quantities of organic waste, have been further amplified by the persistent pace of urbanization, rapid industrial growth, and the relentless expansion of the global population. The culmination of these factors has led to the alarming accumulation of solid waste, with organic waste constituting a significant proportion, thereby giving rise to pressing environmental concerns that urgently call for innovative and sustainable waste management solutions (Kaza *et al*., 2018; Ghinea *et al*., 2020). In response to this burgeoning challenge, the exploration of efficient and ecologically friendly waste management strategy such as vermicomposting has surged to the forefront of environmental research and policy. Vermicomposting is a biologically mediated process that harnesses the intrinsic abilities of earthworms to break down organic matter. It has emerged as an ideal method for the transformation of organic waste into valuable resources (Suthar and Singh, 2008; Atiyeh *et al*., 2015a). Therefore, the mounting apprehensions about the dire environmental repercussions of conventional waste disposal methods, vermicomposting assumes a mantle of significance as a sustainable and eco-conscious alternative (Kale *et al*., 2021). Beyond the usual diversion of organic waste from landfills, vermicomposting capitalizes on the remarkable transformative ability of earthworms to

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elevate the quality of compost produced, thus advancing the cause of waste reduction while simultaneously piloting in the prospect of soil enrichment and bolstering ecosystem sustainability (Ghinea *et al*., 2020). In vermicomposting, the choice of earthworm species assumes pivotal significance, exerting a discernible impact on the efficiency and outcomes of the process. *Eudrilus eugeniae* and *Lumbricus rubellus*, two distinct and notable earthworm species, have emerged as focal points of interest owing to their potential contributions to the vermicomposting milieu. *Eudrilus eugeniae*, commonly known as the African nightcrawler, has earned accolades for its rapidity in composting and its versatility in processing a range of waste materials (Domínguez *et al*., 2010). Concurrently, *Lumbricus rubellus*, a native earthworm species, has substantiated its pivotal role in enhancing soil structural coherence and composing the complex volume of nutrient cycling within ecosystems (Blouin *et al*., 2013). A comparative exploration of the vermicomposting potential of these two species, utilizing cow dung as the foundational substrate, offers an excellent opportunity to unravel their respective efficacies in catalyzing the metamorphosis of organic waste into a clutter of nutrient-laden compost.

Hence, the present study tends to ascertain the comparative efficacy of *Eudrilus eugeniae* and *Lumbricus rubellus* in vermicomposting of cowdung.

MATERIALS AND METHODS

Study Area: The study was carried out at the Zoology laboratory Nnamdi Azikiwe University, Awka (UNIZIK), Anambra State with geographical coordinate of 6°12 N and 7° 4E in the South Eastern zone of Nigeria (Onyido *et al* 2011). It also has a minimum and a maximum average rainfall of about 7mm and 306mm respectively. Awka has an ambient temperature range of 27 ℃ and 34 ℃ respectively.

Procurement of Experimental Substrate: The cowdung was procured from the slaughter area in Amansea, Awka North local government area of Anambra state. While the dry grass was collected from a farm in Unizik.

Experimental Animal: The two species of earthworm used *Eudrilus eugeniae* and *Lumbricus rubellus* were collected from the wild using hand sorting method. The samples were identified using Sims and Gerard 1985, Bouche 1977 and also with aid of Google lens.

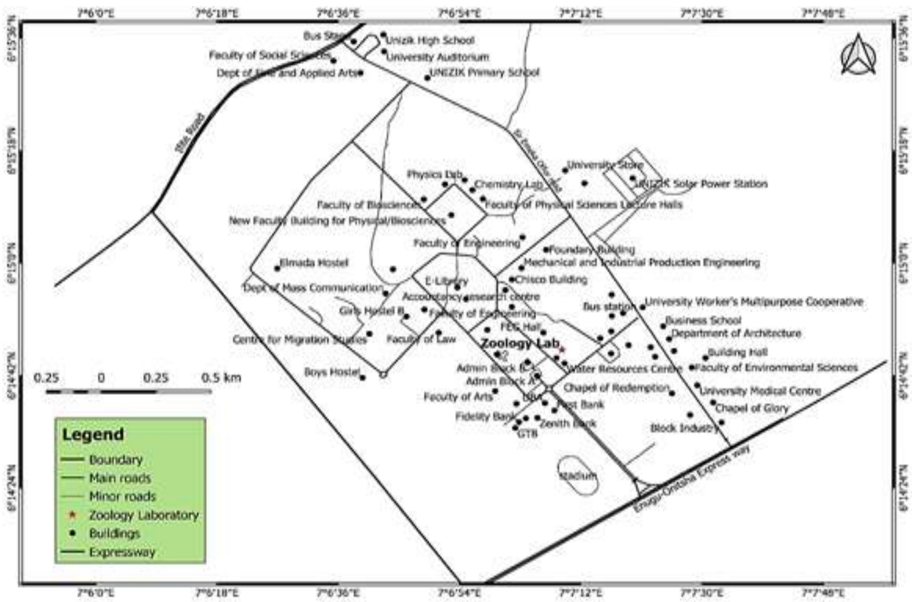

Fig 1: Map of Nnamdi Azikiwe University Awka showing Zoology Lab

Experimental Design: Vermicomposting was conducted in a plastic container 10x8x3m3 in dimensions. Eight (5) different content were prepared/ used. These include: A- Mixture of dry grass with cow dung and one species of earthworm (*Eudrilus eugeniae*), B- Mixture of dry grass with cowdung and *Lumbricus rubellus*, C- Cowdung only and *Eudrilus eugeniae*, D- cowdung only and *Lumbricus rubellus* and E-(Control)-Cowdung without earthworms. Each was replicated twice and kept in a dark room (laboratory) at 25℃ and the vermibins were covered with net to avoid the escape of the earthworms. Ten (10) earthworms were used to 1kg of cowdung in each vermibin (Lim *et al*.2013). The worms were kept in the new environment for two (2) weeks and any form of stress/ disturbances shall be avoided prior the commencement of the research so as to adapt to it. The moisture of the environment was maintained at 60-80% by sprinkling water. After two weeks, the worms were excavated from the simulated environment and washed with distilled water and placed on a filter paper for about 24 hours so that the remains in the gut is excreted. These were used for inoculation of the already prepared vermibin with waste mixture which was left for about 21 days for reduction in the acidity level or toxicity.

Data Collection: Data were collected on weekly basis during the process of vermicomposting for temperature, humidity and pH. The physio-chemical analysis was carried out according to the method of (Association of Official Analytical Chemists, AOAC, 2010).

Statistical Analysis: The data collected were analyzed using analysis of variance (ANOVA) and means were compared by New Duncan Multiple Range Test at 5% probability level using statistical package for social sciences (SPSS) (version 25). Also, Microsoft Excel software package (version 2019) was used for easy interpretation of the results.

RESULTS AND DISCUSSION

The concentration of Physiochemical parameters of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*): The concentration of physiochemical parameters of vermicompost of cow dung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*) is presented in this section. Statistical analysis showed the variations in the physiochemical parameters of different vermicompost. Table 1-7 showed the initial and final values (after 6 weeks) for various parameters across different vermicompost samples. The study involved Cowdung only, cowdung + *Eudrilus eugeniae*, cowdung + dry grass + *Eudrilus eugeniae*, Cowdung + dry grass + *Lumbricus rubellus*, and Cowdung + *Lumbricus rubellus*. These parameters, such as Nitrogen, Potassium, Organic Carbon, Phosphate, % Lignin, Conductivity and Organic Matter, serves as indicators of compost quality and nutrient content. The result of physico-chemical parameters of the cow-dung and *Eudrilus eugeniae*, *Lumbricus rubellus* and dry grass prepared in five different treatments were presented in Table 1 and 7 to understand the baseline composition at the first week and after the influence of earthworms at the 6th week. The examination of the initial concentration of physiochemical parameters in vermicompost samples aimed to establish the difference in the nutrient composition at the first week when there is little or no influence by the earthworms and at the 6th week when there is a significant influence by the earthworms. As presented in the results, various parameters were analyzed across different vermicompost samples: Cowdung only, cowdung + *Eudrilus eugeniae*, cowdung + dry grass + *Eudrilus eugeniae*, Cowdung + dry grass *Lumbricus rubellus*, and Cowdung + *Lumbricus rubellus*. These parameters serve as indicators of compost quality, nutrient content, and the overall transformation process.

Nitrogen Concentration: From Table 1, the initial measurement showed that Nitrogen concentration was highest in the vermi-bed with cow dung and *Lumbricus rubellus* (4.47±0.38) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Eudrilus eugeniae* (2.2±0.141). However, there was a significant difference ($P<0.05$) in the nitrogen concentration among the five vermibeds with different content examined. Conversely, the Nitrogen concentration after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (6.94±0.057) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Eudrilus eugeniae* (4.2±0.141). However, there was a significant difference ($P<0.05$) in the nitrogen concentration among the five vermibeds with different content examined (Table 1). Remarkably, the nitrogen content exhibited a significant increase across all samples after 6 weeks. The increase in Nitrogen content across all vermicompost samples after 6 weeks is a significant observation. This phenomenon can be primarily attributed to the activities of earthworms, specifically the two species studied, *Eudrilus eugeniae* and *Lumbricus rubellus*. Earthworms play a vital role in the vermicomposting process through their feeding and digestion activities. As they consume organic matter, including cow dung and dry grass, they break down complex organic compounds into simpler forms. This breakdown process, also known as mineralization, leads to the release of nutrients, including Nitrogen, in more bioavailable forms (Fu *et al*., 2016). Yatoo *et al*. (2022) further supported these findings by investigating the role of earthworms in nutrient enrichment in vermicomposting. They emphasized that earthworms' gut microbiota contributes to the breakdown of organic materials, releasing nutrients like Nitrogen in forms that plants can readily absorb. The casts produced by earthworms, which are enriched with microbial activities, exhibit increased nitrogen content. This is due to the conversion of organic Nitrogen into ammonium and other soluble forms through microbial enzymatic actions within the earthworm gut (A'ali *et al*., 2017). The dynamic changes in organic matter percentage observed across the vermicompost samples can be attributed to the multifaceted interactions between earthworms and dry grass. These changes align with the findings presented by Lemtiri *et al*. (2014), highlighting the pivotal role of earthworms in organic matter breakdown and moisture regulation within composting systems.

Potassium Concentration: The result showed that the initial potassium concentration was highest in the vermibed with cow dung and *Eudrilus eugeniae* (26.7±0.849) while the least value was obtained in the vermibed cow-dung only (16±0.145). However, there was a significant difference (P<0.05) in the Potassium concentration among the five vermibeds with different content examined. On the other hand, the result showed that Potassium concentration 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (29.49±0.004) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Eudrilus eugeniae* (18.98±0.003). However, there was a significant difference (P<0.05) in the Potassium concentration among the five vermibeds with different content examined (Table 2). Potassium concentrations displayed slight difference. The subtle yet distinct variations observed in potassium concentrations across the vermicompost samples studies by Gómez-Brandón *et al*. (2021) and Maharjan *et al*. (2022), which highlights the role of earthworms in facilitating potassium mobility and redistribution within composting systems. The process enhances potassium's availability and potential for plant uptake (Fu *et al*., 2016; A'ali *et al*., 2017).

Organic Carbon Concentration: The result of the initial organic carbon concentration was highest in the vermibed with cow dung only (30.15±0.495) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Lumbricus rubellus* (24.8±0.990). However, there was a significant difference (P<0.05) in the organic carbon concentration among the five vermibeds with different contents examined. Conversely, the result showed that organic carbon concentration after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (29.49±0.000) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Lumbricus rubellus* (18.98±0.006) However, there was a significant difference (P<0.05) in the nitrogen concentration among the five vermibeds with different content examined (Table 3). The observed shifts in organic carbon content, particularly the decrease over time, align with the study by Domínguez and Gómez-Brandón (2013) and Domínguez *et al*. (2010), shedding light on the enhanced microbial decomposition and earthworm-mediated breakdown processes. Consequently, the decrease in organic carbon content over time can be attributed to the combined effects of microbial and earthworm-mediated breakdown of organic matter (Adetunji *et al*., 2015). Mousavi *et al*. (2020) further supported this notion by examining the impact of earthworms on composting processes. They emphasized that earthworms enhance microbial activities in the compost matrix through their burrowing and casting actions.

Organic Matter content: The result showed that the initial organic matter concentration was highest in the vermibed with cow dung mixed with dry grass and *Eudrilus eugeniae* (33.15±0.919) while the least value was obtained in the vermibed with cow-dung only (3.93±0.177). However, there was a significant difference (P<0.05) in the organic matter concentration among the five vermibeds with different contents examined. Moreover, the result showed that organic matter content after 6 weeks was highest in the vermibed with cow dung and *Eudrilus eugeniae* (23.96±0.006) while the least value was obtained in the vermibed with cow-dung only (4.7±0.003). However, there was a significant difference (P<0.05) in the organic matter content among the five vermibeds with different content examined 6 weeks (Table 4). The dynamic changes in organic matter percentage observed across the vermicompost samples can be attributed to the multifaceted interactions between earthworms and dry grass. These changes align with the findings presented by Lemtiri *et al*. (2014), highlighting the pivotal role of earthworms in organic matter breakdown and moisture regulation within composting systems.

Phosphate Concentration: The result showed that the phosphate concentration was highest in the vermibed with cow dung and *Lumbricus rubellus* (114.64±0.648) while the least value was obtained in the vermibed cowdung mixed with dry grass and *Lumbricus rubellus* (7.51±0.438). However, there was a significant difference (P<0.05) in the phosphate concentration among the five vermibeds with different contents examined. On the other hand, the result showed that Phosphate concentration after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (119.7±0.006) while the least value was obtained in the vermibed of cow-dung mixed with dry grass and *Eudrilus eugeniae* (17.61±0.006) However, there was a significant difference (P<0.05) in the Phosphate concentration among the five vermibeds with different contents examined (Table 5).

Table 1: Nitrogen Concentration of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Nitrogen %	
Vermibeds	**Initial**	**After 6 weeks**
Cowdung only	3.1±0.424[a]	5.3±0.141[c]
Cowdung + *Eudrilus eugeniae*	4.15±0.495[b]	6.72±0.057[d]
Cowdung +dry grass+*Eudrilus eugeniae*	2.2±0.141[a]	4.2±0.141[a]
Cowdung + dry grass *Lumbricus rubellus*	2.5±0.141[a]	4.8±0.283[b]
Cowdung + *Lumbricus rubellus*	4.47±0.38[b]	6.94±0.057[d]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 2: Potassium Concentration of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Potassium (ppm)	
Vermibeds	**Initial**	**Final**
Cowdung only	16±0.145[a]	20.68±0.003[c]
Cowdung + *Eudrilus eugeniae*	19.50±0.849[b]	20.99±0.01[d]
Cowdung +dry grass+*Eudrilus eugeniae*	18.73±0.742[b]	18.98±0.003[a]
Cowdung + dry grass *Lumbricus rubellus*	18.95±0.778[b]	19.45±0.064[b]
Cowdung + *Lumbricus rubellus*	19.29±0.614[b]	29.49±0.004[d]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 3: Organic Carbon of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Organic carbon (%)	
Vermibeds	**Initial**	**Final**
Cowdung only	30.15±0.495[d]	23.9±0.009[c]
Cowdung + *Eudrilus eugeniae*	27.93±0.948[bc]	24.99±0.001[d]
Cowdung +dry grass+*Eudrilus eugeniae*	26.69±0.297[ab]	21.85±0.011[b]
Cowdung + dry grass *Lumbricus rubellus*	24.8±0.990[a]	18.98±0.006[a]
Cowdung + *Lumbricus rubellus*	29.54±0.949c[d]	29.49±0.000[d]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 4: Organic Matter content of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Organic matter (%)	
Vermibeds	**Initial**	**Final**
Cowdung only	3.93±0.177[a]	4.7±0.003[b]
Cowdung + *Eudrilus eugeniae*	30.63±0.608[c]	23.96±0.006[e]
Cowdung +dry grass+*Eudrilus eugeniae*	33.15±0.919[d]	23.49±0.004[d]
Cowdung + dry grass *Lumbricus rubellus*	29.25±0.778[c]	21.08±0.001[c]
Cowdung + *Lumbricus rubellus*	9.6±0.283[b]	4.53±0.007[a]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 5: Phosphate Concentration of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Phosphate (mg/kg)	
Vermibeds	**Initial**	**Final**
Cowdung only	25.5±1.414[c]	28.22±0.004[c]
Cowdung + *Eudrilus eugeniae*	90.64±1.817[d]	95.75±0.004[d]
Cowdung +dry grass+*Eudrilus eugeniae*	7.51±0.438[a]	17.61±0.006[a]
Cowdung + dry grass *Lumbricus rubellus*	7.95±0.990[a]	20.07±0.004[b]
Cowdung + *Lumbricus rubellus*	114.64±0.648[d]	119.7±0.006[e]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 6: Lignin Concentration of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

	Lignin (%)	
Substrate	**Initial**	**Final**
Cowdung only	15.18±0.389[bc]	10.68±0.085[b]
Cowdung + *Eudrilus eugeniae*	17.2±0.849[c]	13.89±0.042[d]
Cowdung +dry grass+*Eudrilus eugeniae*	19.78±0.396[d]	12.74±0.057[c]
Cowdung + dry grass *Lumbricus rubellus*	14.64±0.792[b]	9.54±0.042
Cowdung + *Lumbricus rubellus*	10.92±1.298[a]	14.8±0.071[d]

Columns sharing similar superscript are not significantly different (p<0.05)

The prominent fluctuations in phosphate levels across the vermicompost samples after 6 weeks find support in studies by Onwudike (2010) and Vakili *et al*. (2015), which highlighted the vital role of earthworms in processing and enriching nutrients, particularly phosphorus, in composting systems. Earthworms' digestive processes lead to the transformation of organic phosphorus compounds into more soluble and plant-available forms. As a result, the vermicompost becomes enriched with accessible phosphorus that can support plant growth and development (Yadav and Garg, 2009).

Lignin Concentration: The result showed that the initial lignin concentration was highest in the vermibed with cow dung mixed with dry grass and *Eudrilus eugeniae* (19.78±0.396) while the least value was obtained in the vermibed cowdung and *Lumbricus rubellus* (10.92±1.298). However, there was a significant difference (P<0.05) in the lignin concentration among the five vermibeds with different contents examined. On the other hand, the result showed that lignin content after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (14.8±0.071) while the least value was obtained in the vermibed with cow-dung mixed with dry grass and *Eudrilus eugeniae* (9.54±0.042). However, there was a significant difference (P<0.05) in the lignin content among the five vermibeds with different contents examined (Table 6). The observed variability in % Lignin content across the vermicompost samples after 6 weeks is consistent with studies conducted by Singh and Sharma (2002) and Bhat *et al*. (2017). These studies shed light on the multifaceted mechanisms through which earthworms impact lignin degradation, ultimately influencing its presence within the vermicompost.

Table 7: Conductivity of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

Substrate	Conductivity (usm/cm) Initial	Final
Cowdung only	55.4±0.424[a]	51.9±0.566[a]
Cowdung + *Eudrilus eugeniae*	57.5±0.424[c]	52.8±0.566[a]
Cowdung +dry grass+*Eudrilus eugeniae*	56.25±0.354[ab]	54±0.000[b]
Cowdung + dry grass *Lumbricus rubellus*	58.6±0.283[d]	55.95±0.212[c]
Cowdung + *Lumbricus rubellus*	56.5±0.283[b]	54.2±0.283[b]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 8: Moisture Content of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

Vermibeds	Moisture (%) Initial	Final
Cowdung only	80.1±0.141[d]	61.14±0.013[e]
Cowdung + *Eudrilus eugeniae*	70.25±1.485[c]	50.25±0.004[c]
Cowdung +dry grass+*Eudrilus eugeniae*	62.55±1.414[ab]	37.64±0.003[b]
Cowdung + dry grass *Lumbricus rubellus*	65.2±0.99[b]	35.48±0.004[a]
Cowdung + *Lumbricus rubellus*	60.2±1.838[a]	55.81±0.007[d]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 9: pH concentration of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

Vermibeds	pH Initial	Final
Cowdung only	6.88±0.177[a]	7.83±0.184[a]
Cowdung + *Eudrilus eugeniae*	7.03±0.099[a]	7.25±0.778[a]
Cowdung +dry grass+*Eudrilus eugeniae*	7.1±0.113[a]	7.3±0.141[a]
Cowdung + dry grass *Lumbricus rubellus*	8.08±0.113[a]	7.1±0.141[a]
Cowdung + *Lumbricus rubellus*	7.5±1.061[a]	8.2±0.424[a]

Columns sharing similar superscript are not significantly different (p<0.05)

Table 10: Temperature of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

Vermibed	Temperature (℃) Initial	Final
Cowdung only	29.5±0.566[a]	28±0.071[a]
Cowdung + *Eudrilus eugeniae*	30.1±0.283[a]	28±1.131[a]
Cowdung +dry grass+*Eudrilus eugeniae*	29.7±0.424[a]	28.2±0.141[a]
Cowdung + dry grass *Lumbricus rubellus*	29.3±0.99[a]	28.1±0.283[a]
Cowdung + *Lumbricus rubellus*	28.8±0.354[a]	27.7±0.141[a]

Columns sharing similar superscript are not significantly different (p<0.05)

Earthworm-mediated modifications of microbial communities create an environment conducive to lignin degradation, contributing to the observed variability in lignin content (Biruntha *et al*., 2020). *Electrical Conductivity:* The result showed that the initial conductivity was highest in the vermibed with cow dung mixed with dry grass and *Lumbricus rubellus* (58.6±0.283) while the least value was obtained in the vermibed with cowdung only (55.4±0.424). However, there was a significant difference (P<0.05) in the conductivity among the five vermibeds with different contents examined. Furthermore, the result showed that Nitrogen concentration after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (55.95±0.212) while the least value was obtained in the vermibed with cowdung only (51.9±0.566). However, there was a significant difference (P<0.05) in the conductivity among the five vermibeds with different contents examined (Table 7). Kim *et al*. (2017) extended this understanding by examining the role of earthworms in ion mobility within composting systems. Their findings indicated that earthworms' feeding behaviors lead to the mixing of organic matter and soil components, creating a more homogenous and interconnected matrix.

The result of environmental variables of vermicompost using cow dung mixed with grass and two species of earthworms (Eudrilus eugeniae and Lumbricus rubellus): The result of environmental variables (moisture, pH and temperature) of vermicompost using cow dung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*) is presented in Table 8-10. Statistical analysis showed the variations in the environmental variables of vermicompost in the study which include cowdung only, cowdung + *Eudrilus eugeniae*, cowdung +dry grass+*Eudrilus eugeniae*, cowdung + dry grass + *Lumbricus rubellus* and Cowdung + *Lumbricus rubellus.* Examining the concentration of physiochemical parameters after 6 weeks of vermicomposting (Table 8-10) provides insights into the changes brought about by the activities of earthworms. This assessment allows us to understand how these factors influence the compositional dynamics over time. Similar to the initial study, the different vermicompost variants were evaluated for their nitrogen, potassium, organic carbon, organic matter, phosphorus, lignin, conductivity, and moisture content. Comparing the baseline data with the final data after six weeks reveals trends and shifts that can be attributed to the activities of earthworms and the interactions within the vermicomposting system (vermi-bed).

Moisture Content: The result showed that the initial moisture content was highest in the vermibed with cow dung only (80.1±0.141) while the least value was obtained in the vermibed of cowdung mixed with dry grass and *Eudrilus eugeniae* (60.2±1.838) However, there was a significant difference (P<0.05) in the moisture content of the five vermibeds with different contents examined.

Conversely, the result showed that the moisture content after 6 weeks was highest in the vermibed with cow dung only (61.14±0.013) while the least value was obtained in the vermibed with cow-dung mixed with dry grass and *Eudrilus eugeniae* (35.48±0.004) However, there was a significant difference ($P<0.05$) in the nitrogen concentration among the five vermibeds with different contents examined (Table 8). The shifts in conductivity and moisture content observed across the vermicompost samples can be attributed to the effects of earthworms, as highlighted by studies conducted by Manyuchi, and Phiri (2013) and Kim *et al*. (2017).

pH: The result showed that the initial pH value was highest in the vermibed with cow dung mixed with dry grass and *Lumbricus rubellus* (8.08±0.113) while the least value was obtained in the vermibed of cowdung mixed with dry grass and *Eudrilus eugeniae* (7.1±0.1131). However, there was no significant difference ($P<0.05$) in the pH among the five vermibeds with different contents examined. On the other hand, the result showed that the pH value after 6 weeks was highest in the vermibed with cow dung mixed with dry grass and *Eudrilus eugeniae* (8.2±0.424) while the least value was obtained in the vermibed cowdung and *Lumbricus rubellus* (7.1±0.141). However, there was no significant difference ($P<0.05$) in the pH among the five vermibeds with different contents examined (Table 9).

Temperature: The result showed that the initial temperature was highest in the vermibed with cow dung and *Eudrilus eugeniae* (30.1±0.283) while the least value was obtained in the vermibed with cowdung and *Lumbricus rubellus* (28.8±0.354). However, there was no significant difference ($P<0.05$) in the temperature among the five vermibeds with different content examined. Conversely, the result of the study showed that the temperature variation after 6 weeks was highest in the vermibed with cow dung and *Lumbricus rubellus* (28.2±0.141) while the least value was obtained in the vermibed of cowdung mixed with dry grass and *Lumbricus rubellus* (27.7±0.141). However, there was no significant difference ($P<0.05$) in the temperature among the five vermibeds with different contents examined (Table 10). Comparing the baseline data and that collected after 6 weeks, it becomes evident that both pH and temperature have undergone alterations after 6 weeks of vermicomposting. The pH values show fluctuations, with some samples experiencing an increase while others show a decrease. This observation can be attributed to the metabolic activities of earthworms and the microbial communities they foster. A study by Xiao *et al*. (2020) suggested that earthworm activities influence pH through their digestion and casting processes, altering the composition of the vermicompost matrix. Similarly, temperature variations can be linked to microbial activities and the thermal regulation mechanisms within the vermicompost. The changes in temperature reflect the dynamics of microbial communities, as mentioned in the study of García *et al*. (2023).

Percentage decomposition of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (Eudrilus eugeniae and Lumbricus rubellus): The percentage decomposition of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*) after 6 weeks was presented in figure 1. Analysis showed the variations in the percentage decomposition of vermicompost in the study which include cowdung only, cowdung + *Eudrilus eugeniae*, cowdung +dry grass+*Eudrilus eugeniae*, Cowdung + dry grass + *Lumbricus rubellus* and Cowdung + *Lumbricus rubellus*. The result of the study was further explained using figure 1. The result showed that the percentage decomposition was highest in the vemibed with cowdung +dry grass+*Eudrilus eugeniae* (79.9%) followed by cowdung + *Eudrilus eugeniae* (74.27%) while the least was recorded in vermi-bed with cow dung only (43.48%) (figure 1). The highest percentage decomposition or rate of decomposition in the five vermibeds was observed in the vermibed with Cowdung +E. eugeniae (79.90%) while the least was observed in the vermibed with Cowdung only. This phenomenon can be primarily attributed to the activities of earthworms, specifically the two species studied, *Eudrilus eugeniae* and *Lumbricus rubellus*. Earthworms play a vital role in the vermicomposting process through their feeding and digestion activities. As they consume organic matter, including cow dung and dry grass, they break down complex organic compounds into simpler forms. Earthworms are considered an effective part of the decomposer community, and play a key role in plant material decomposition and increase the rate of turnover of organic matter (Ernst *et al*., 2009; Gomez-Brandon *et al*., 2010; Lubbers *et al*., 2017). Sharma *et al*. (2005), reported that earthworms of different species and ecological categories differed greatly in their ability to digest various organic matter. Hence, probably, the reason the decomposition rate *E.eugeniae* was higher. Aira *et al*. (2006) evaluated the role of *Eudrilus eugeniae* in cellulose decomposition, by conducting an experiment on pig slurry with microbial rich substrate in small-scale vermireactors with and without earthworms. The activity of *Eudrilus eugeniae* triggered fungal growth during vermicomposting which led to more intense and efficient cellulolysis. The presence of fungi during vermicomposting process is an additional supplement to the earthworms that contributed to the increased number and weight of the earthworms.

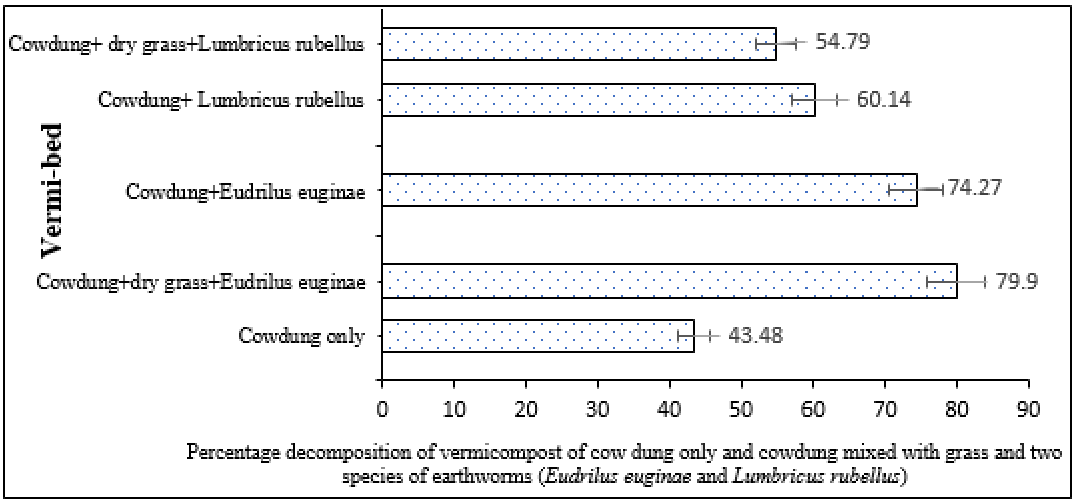

Fig 1: Percentage decomposition of vermicompost of cow dung only and cowdung mixed with grass and two species of earthworms (*Eudrilus eugeniae* and *Lumbricus rubellus*)

Conclusion: This study confirmed that the two species of earthworms, *Eudrilus eugeniae* and *Lumbricus rubellus* are both effective in decomposing cowdung. It is recommended that any of the two species can be used for effective vermicomposting.

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