



**Activity Pattern of *Eudrilus eugeniae* (African Nightcrawler)
and *Lumbricus terrestris* (Common Earthworm) in an
Organic Composting System.**

by

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DECLARATION

I declare that this thesis entitled “Activity Pattern of *Eudrilus eugeniae* (African Nightcrawler) and *Lumbricus terrestris* (Common Earthworm) in an Organic Composting System” is the output of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

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ACTIVITY PATTERN OF *EUDRILUS EUGENIAE* (AFRICAN NIGHT CRAWLER) AND *LUMBRICUS TERRESTRIS* (COMMON EARTHWORM) IN AN ORGANIC COMPOSTING SYSTEM

ABSTRACT

Composting organic waste produces nutrient-rich soil amendments, which are essential for expanding agriculture and managing trash sustainably. Earthworms improve the nutrient cycle and soil structure, which helps this process along. Important species that affect composting effectiveness include the *Eudrilus eugeniae* (African Nightcrawler) and *Lumbricus terrestris* (Common Earthworm). These species have different eating habits and environmental requirements. Despite their ecological significance, little is known about their precise feeding preferences and activity patterns in organic composting systems. The purpose of this research is to better understand how these earthworms behave in these kinds of settings by looking at their preferred substrates and how environmental elements like pH, moisture content, and temperature affect their eating patterns. The study also evaluates their efficiency as detritivores and how their activity affects the results of sustainable farming methods, improve waste management, and optimize composting procedures. After one (1) week of conducting this experiment, we could conclude that, *Edrilus.eugeniae* (African Nightcrawler) is the most effective in conducting the composting method. In conclusion, between two species (*Eudrilus.eugeniae* and *Lumbricus terrestris*) that has been chosen, we recommend using *Eudrilus eugeniae* (African Nightcrawler) to conduct organic composting.

Keywords: organic composting, earthworms, nutrient cycling, *Eudrilus eugeniae*, *Lumbricus terrestris*, sustainable agriculture, detritivores, compost quality.

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**POLA AKTIVITI *EUDRILUS EUGENIAE* (CACING MALAM AFRIKA) DAN
LUMBRICUS TERRESTRIS (CACING TANAH BIASA) DALAM SISTEM
PENGOMPOSAN ORGANIK**

ABSTRAK

Pengkomposan sisa organik menghasilkan bahan tambah tanah yang kaya dengan nutrien, yang penting untuk mengembangkan pertanian dan mengurus sisa secara mampan. Cacing tanah memperbaiki kitaran nutrien dan struktur tanah, yang membantu proses ini. Spesies penting yang mempengaruhi keberkesanan pengkomposan termasuk *Eudrilus eugeniae* (cacing malam Afrika) dan *Lumbricus terrestris* (cacing tanah biasa). Spesies-spesies ini mempunyai tabiat pemakanan dan keperluan persekitaran yang berbeza. Walaupun kepentingan ekologi mereka, masih sedikit yang diketahui tentang keutamaan pemakanan dan corak aktiviti mereka yang tepat dalam sistem pengkomposan organik. Tujuan penyelidikan ini adalah untuk lebih memahami bagaimana cacing tanah ini berkelakuan dalam persekitaran seperti ini dengan melihat substrat yang mereka gemari dan bagaimana elemen persekitaran seperti pH, kandungan kelembapan, dan suhu mempengaruhi corak pemakanan mereka. Kajian ini juga menilai kecekapan mereka sebagai detritivor dan bagaimana aktiviti mereka mempengaruhi hasil kaedah pertanian mampan, meningkatkan pengurusan sisa, dan mengoptimumkan prosedur pengkomposan. Selepas satu (1) minggu menjalankan eksperimen ini, kami dapat membuat kesimpulan bahawa *Eudrilus eugeniae* (cacing malam Afrika) adalah yang paling berkesan dalam menjalankan kaedah pengkomposan. Kesimpulannya, antara dua spesies (*Eudrilus eugeniae* dan *Lumbricus terrestris*) yang telah dipilih, kami mengesyorkan menggunakan *Eudrilus eugeniae* (cacing malam Afrika) untuk menjalankan pengkomposan organik.

Keywords: pengkomposan organik, cacing tanah, kitaran nutrien, *Eudrilus eugeniae*, *Lumbricus terrestris*, pertanian mampan, detritivor, kualiti kompos.

TABLE OF CONTENTS

DECLARATION	i
ACKNOWLEDGEMENT	ii
ABSTRACT.....	iii
ABSTRAK.....	iv
TABLE OF CONTENTS	1
LIST OF TABLES	3
LIST OF FIGURES	4
INTRODUCTION	5
1.1 Background of study	5
1.2 Problem Statement	7
1.3 Objective of Study	7
1.4 Scope of Study	7
1.5 Significance of Study	8
LITERATURE REVIEW	9
2.1 Classification of Earthworm	9
2.2 Morphology of Earthworm	9
2.3 Life Cycle of Earthworm	11
2.4 Origin, Habitats and Distribution of Earthworm	11
2.5 Earthworm common source of food	12
2.6 Pests and Diseases of Earthworm	12
2.7 Organic composting system	13
2.8 Feeding Behavior of earthworm species.....	14
2.9 Effectiveness of earthworm species as detritivore.....	15
2.10 Activity pattern of earthworm species	16
MATERIALS AND METHODS.....	17
3.1 Experimental Setup.....	17
3.2 Assessing the activity pattern and feeding behavior of two different species – <i>Lumbricus terrestris</i> (Common earthworm), and <i>Eudrilus eugeniae</i> (African nightcrawler).....	21

3.3 Assessing the most effective earthworm as detritivore in organic composting system.....	22
3.4 Data Analysis	22
RESULT AND DISCUSSION	25
4.1 Activity Pattern of <i>Lumbricus terrestris</i> (Common earthworm) and <i>Eudrilus eugeniae</i> (African Night Crawler) in soil enclosures.....	25
4.2 Effectiveness of earthworms <i>spp.</i> in decomposing organic waste.....	35
CONCLUSION AND RECOMMENDATION	39
5.1 Conclusion	39
5.2 Recommendation.....	40
REFERENCES	42
APPENDIX A.....	46
APPENDIX B.....	48



LIST OF TABLES

No.	TITLE	PAGE
4.1	Total of daily frequency of activity pattern of earthworm <i>spp.</i>	25
4.2	Chi-square test comparison of six activity patterns	33
4.3	Chi-square test comparison of location of earthworm <i>spp.</i>	34
4.4	Decomposition rate (%) of organic composting system	35



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LIST OF FIGURES

No.	TITLE	PAGE
2.0	Morphology of Earthworm	10
3.0	Models of Soil Enclosure	18
3.1	Model of Soil Enclosure in 3D	18
3.2	Model of Soil Box	19
3.4	Materials for Food Waste	20
4.1	Result of Activity Pattern for 7 days	28
4.2	Activity Pattern of <i>Eudrilus eugeniae</i>	29
4.3	The Frequency of Activity Pattern of <i>Eudrilus eugeniae</i>	30
4.4	Activity Pattern of <i>Lumbricus terrestris</i>	30
4.5	The Frequency of Activity Pattern of <i>Lumbricus terrestris</i>	31
4.6	The Effectiveness of Earthworm <i>spp.</i>	34

CHAPTER 1

INTRODUCTION

1.1 Background of study

According to Rajapaksha *et al.*, (2016), organic composting generates nutrient rich soil amendments that are beneficial to both agriculture and the environment, making it a crucial technique for sustainable waste management and agricultural expansion. Earthworms are essential to this process because they improve soil structure and nutrient cycling through their burrowing and feeding behaviours (Brown *et al.*, 2015). In composting systems, a variety of earthworm species are commonly employed since they are crucial to the decomposition and nutrient cycling processes. According to Domínguez and Edwards (2010), *Eudrilus eugeniae*, commonly referred to as African nightcrawler, has been acknowledged for its contributions to improving soil fertility in composting condition. Additionally, *Lumbricus Terrestris*, also known as the Nightcrawler or common earthworm, is studied by Hendriksen and Hauser (2006) to find out how it affects the quantity and activity of soil microbes in greenhouse pot trials. When taken as a whole, these studies highlight the diverse functions that distinct earthworm species perform in controlling and composting organic waste, highlighting their significance in sustainable farming practices. Each of these species displays distinct feeding preferences and behaviours that have an impact on the rate at which organic

waste decomposes and the dynamics of the nutrient cycle inside the composting system (Domínguez, 2004).

Earthworms indicate selective preferences for specific organic materials based on their chemical and physical composition, and environmental conditions such as temperature, moisture content, and pH levels can have an impact on how they feed (Arshad & Lowery, 2008; González *et al.*, 2017). Understanding these preferences is crucial for optimizing the composting process and nutrient transformation, which enhances waste management and agricultural productivity (Airaksinen *et al.*, 2016).

The fact that there is still a large knowledge gap about the specific feeding preferences and activity pattern of various earthworm species in the context of organic composting systems serves as a reminder of the need for additional research (Edwards & Bohlen, 1996). Previous research has examined the impact of earthworm activity on the decomposition of organic matter and the release of nutrients in various composting systems. The purpose of this study is to investigate how several different kinds of earthworms behave in an organic composting system. In order to maximize soil fertility and nutrient cycling for sustainable waste management and agricultural productivity, this study will look at the preferences of the animals for various organic substrates and the effects of important environmental parameters on their feeding habits.

1.2 Problem Statement

The development of efficient and sustainable waste management strategies is hindered by the significant knowledge gap that exists regarding the specific activity pattern of earthworm species and its implications for composting efficiency, despite the fact that earthworms play a crucial role in organic composting systems.

1.3 Objective of Study

- 1) To study the activity pattern of *Lumbricus terrestris* (Common earthworm) and *Eudrilus eugeniae* (African Nightcrawler) in an organic composting system.
- 2) To determine the most effective earthworm as detritivore in an organic composting system.

1.4 Scope of Study

This study's scope includes a close examination of the activity pattern of a few different species of earthworms, particularly are, *Lumbricus terrestris* (Common Earthworm), and *Eudrilus eugeniae* (African Nightcrawler), in the context of organic composting systems. It attempts to shed light on their preferences and actions in relation to different organic substrates frequently used in composting procedures, while considering the impact of important environmental parameters including temperature swings, moisture content, and substrate compositions.

Additionally, the study will evaluate how earthworm activity pattern and feeding habits affect the effectiveness of the composting process, with a focus on the worms' contributions to nutrient cycling and organic matter decomposition. The quality of the resulting compost will also be examined, with an emphasis on alterations

in nutrient composition, microbial activity, and the compost's general stability. It seeks to offer useful insights into the potential applications of earthworm mediated composting in sustainable agriculture practices while acknowledging the restrictions and limitations inherent in such a study.

1.5 Significance of Study

The importance of this study rests in its prospective benefits to agricultural production as well as sustainable waste management. The goal of the research is to provide a thorough understanding of the activity pattern of two important earthworm species in the context of organic composting systems: *Lumbricus terrestris* and *Eudrilus eugeniae*. This will help to improve the effectiveness of composting and nutrient transformation. Composting solutions can be developed more effectively by considering the unique preferences and behaviours of these earthworm species in respect to different organic substrates and environmental factors. This information can result in improved waste management techniques that encourage the rapid breakdown of organic material and the addition of vital nutrients to compost.

A further benefit of the study's research of compost quality is that it can help produce high-quality organic fertilizers by revealing changes in nutrient composition and microbial activity. This will support sustainable agriculture practices. The study's overall conclusions can help to develop efficient and environmentally friendly composting methods, which will ultimately support sustainable agriculture and the preservation of natural resources.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification of Earthworm

A diverse group of segmented worms essential to soil fertility and nutrient cycling are called earthworms. According to Edwards and Bohlen (1996), they belong to the phylum Annelida and class Oligochaeta.

Numerous families, like the *Lumbricidae*, *Megascolecidae*, and *Eudrilidae*, have distinct anatomical traits and ecological preferences that aid in their taxonomic classification (Blakemore, 2000).

Earthworms, also known as angleworms, belong to the class Oligochaeta of the phylum Annelida, which also contains over 1,800 other terrestrial species, the majority of which are in the genus *Lumbricus*. In the eastern United States, there are seventeen native species and thirteen invasive species from Europe, with *Lumbricus terrestris* being the most prevalent. Almost any soil in the world that has adequate organic matter and moisture to maintain them will include earthworms. The most thorough study of earthworm behaviour was done by English naturalist Charles Darwin.

2.2 Morphology of Earthworm

Earthworms digest and circulate nutrients thanks to their segmented body, isolated circulatory system, and muscular pharynx (Bouché, 1977). Their cuticle, which consists of a moist protective covering that makes it easier for them to move

through the soil and breathe, highlights their capacity to adapt to a range of ecological niches (Lavelle, 1988).

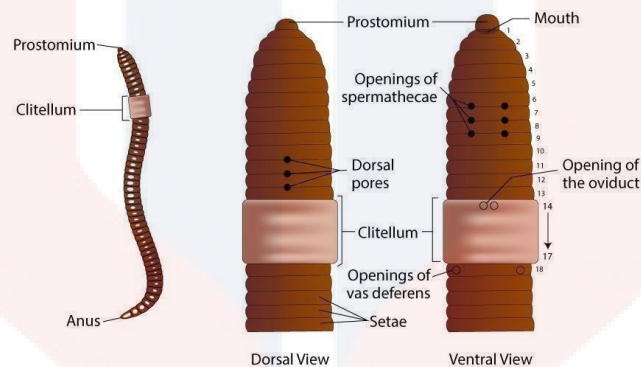


Figure 2.0 Morphology of earthworm – Retrieved from GeeksforGeeks. (n.d.).

Based on the picture above, the prostomium, a distinctive lobe at the front end of an earthworm, protects its mouth and facilitates its movement through soil by pushing gaps and fractures open. The wedgelike structure of the prostomium may help earthworms more readily navigate compacted soil and complete their burrowing activities, according to study by Anderson and Smith (2019).

The clitellum, a noticeable structure that resembles a collar and is situated close to the anterior end of the earthworm's body, is an essential component in reproduction. It has a role in both egg laying and cocoon building. According to research by Brown and Johnson (2020), the clitellum secretes a mucus that aids in the construction of cocoons and shields developing eggs during reproduction.

2.3 Life Cycle of Earthworm

Earthworms go through a complex life cycle that includes emerging from cocoons, developing into juveniles, and reaching adulthood—when they are sexually reproducing—according to Edwards (2004). The construction of protective cocoons and the subsequent growth of embryos inside them are critical life cycle stages that ensure the survival and multiplication of earthworm populations (James & Butt, 2004).

2.4 Origin, Habitats and Distribution of Earthworm

According to Hendrix *et al.*, (2008), earthworms are found in a range of terrestrial habitats, including fields, woodlands, and grasslands. They are scattered around the world. The availability of organic matter, soil moisture content, and soil composition influence their distribution patterns and, consequently, the ecological roles they play in different habitats (Blakemore, 2000).

It is believed that after being introduced to Europe, the earthworm species *Lumbricus terrestris*—also known as the Nightcrawler or common earthworm—spread over the continent. These earthworms help with soil aeration and nutrient cycling in moist soil environments such as grasslands, forests, and agricultural areas. According to a study conducted by Brown and Smith (2019), *Lumbricus terrestris* is found widely across North America, Europe, and some parts of Asia. In a range of environments, it is crucial for enhancing soil fertility and structure.

The African nightcrawler, *Eudrilus eugeniae*, is indigenous to the tropical regions of West Africa, which include Nigeria and Ghana (Edwards, 2004). These earthworms do well in rich organic settings like forest floors, plantations, and agricultural fields because they are well suited to warm, humid conditions (Reinecke

& Viljoen, 1982). They are frequently found in soils that are moist, well-drained, and rich in organic matter. In these conditions, they are essential for the cycling of nutrients and the improvement of soil fertility. Furthermore, because of its adaptability to a variety of soil and climate conditions, *Eudrilus eugeniae* has been brought to many parts of the world for the purpose of vermicomposting and has even grown naturalized in some tropical and subtropical places (Edwards, 2004).

2.5 Earthworm common source of food

Earthworms are also known to actively consume waste materials like dead roots, plant litter, and fallen leaves (Brown and Johnson, 2020). These feeding processes increase soil fertility and enable nutrient release by dissolving complex organic compounds into simpler forms.

The study also highlights how earthworms aid in soil aggregation and the casting process, which enriches the soil with organic materials. The organic nutrients added to these castings improve the soil's structure, ability to hold onto water, and availability of nutrients. Plant development and the ecosystem's overall productivity are aided by this.

2.6 Pests and Diseases of Earthworm

Many pests and diseases, including fungal pathogens and parasitic nematodes, can reduce the population and ecological roles of earthworms (Hendrix *et al.*, 2008). The potential for these risks to be made worse by alterations in soil pH and

the use of chemical inputs emphasizes the need for sustainable pest management strategies (James & Butt, 2004).

2.7 Organic composting system

Based on the literature review "Composting of Organic Solid Waste of Municipal Origin: The Role of Research in Enhancing Its Sustainability" written by Policastro & Cesaro, in 2022, an environmentally friendly way to recycle organic waste and make organic fertilizer is by composting. The improvement of composting systems' sustainability and efficacy has been greatly aided by research. In order to determine the role of research in improving compost quality and minimizing negative effects on the environment and human health, a thorough analysis of the growing body of research on composting is necessary.

A review of "Composting and its application in bioremediation of organic contaminants" written by Lin *et al.*, in 2022 also draws attention to the advancements made in the field of composting research, especially in terms of speeding up the composting process and improving its quality. Vermicomposting is a quicker way to reduce organic waste than regular composting since it uses earthworms' natural breakdown process (Angima *et al.*, 2011). Earthworms are used in the vermicomposting process, which is comparable to regular composting except that they physically break up the organic material and enhance turnover and aeration, which raises the activity rates of other microbiological organisms (Faires, 2022).

The decomposition process begins when earthworms consume organic resources such as compost, rotting roots, or fallen leaves. Worm castings are a material excreted by them during eating that is rich in nutrients and beneficial soil microbes; it is also known as vermicompost (Kenneth, 2023). Vermicomposting uses the

microbiological activity of earthworms to decompose organic waste more quickly than traditional composting. Earthworms are crucial to sustainable agricultural practices such organic farming, conservation tillage, and agroforestry because they preserve soil health and productivity (Kenneth, 2023).

Based on the research conducted by Yüksek, T. (2022), they used some different medium to measure the feeding behavior of Redworm (*Eisenia fetida*). They were ready to use earthworms to generate vermicompost from hazelnut husk (100%), tea plant waste (100%), hazelnut husk (A) (50%) + tea plant waste (B) (50%), hazelnut husk (A) (30%) + tea plant waste (30%) + cow dung (20%) + sawdust (15%) + discarded newspaper (5%).

2.8 Feeding Behavior of earthworm species

Feeding behavior is a fundamental aspect of animal survival and is influenced by the diversity of foods consumed and the vast array of animal species. The feeding behavior of earthworm spp. in this study will include the dietary of earthworm species, type of eater whether diurnal or nocturnal, and also duration they eat. The dietary habits that animals acquire are the result of the evolutionary interaction between anatomical processes and environmental conditions (Ruiter,2023). It is commonly recognized that earthworms may eat a broad range of organic materials that are present in soil. Piercy (2022) claims that earthworms have tiny mouths that they use to crush and consume detritus, which is present on the soil's surface and comprises fungi, bacteria, leaves, roots, and other things. Being surrounded by food virtually all

the time eliminates their need to go hunting. Earthworms dig tunnels beneath the surface to find food, which they subsequently consume (Piercy, 2022).

Despite being vital to many soil ecosystems, not much quantitative information is known about the food preferences of earthworms. But this knowledge is very helpful to the studies on earthworm energy budgets (Bolton and Phillipson, 1976), nutrient cycling in ecosystems (Whalen *et al.*, 1999), removal of dung from pastures (Hendriksen, 1991), and chemical absorption by earthworms from their diet (Jager, 2003). Since most earthworm activity takes place below the surface, it can be difficult to monitor and observe eating behavior without disturbing the worms. Although it could seem that earthworms just eat soil particles at a fixed rate without making any distinctions, a few examples demonstrate that the truth is more complex.

The research currently in publication does not provide much information about the diurnal or nocturnal behaviors of earthworms in composting systems. However, some studies have examined the spatial interactions and burrowing behaviors of different species of earthworms, which can provide insight into their activity patterns. For example, research conducted by Capowiez, Y. (2000) study looked into the differences in the burrowing patterns and spatial interactions of two species of earthworms: *Aporrectodea nocturna* and *Allobophora chlorotica*.

2.9 Effectiveness of earthworm species as detritivore

These worms are native to tropical regions, reproduce and develop quickly, and have the ability to break down waste (Dominguez *et al.*, 2001). They are perfect for tropical vermicomposting systems since they can tolerate a wide range of temperatures (Dominguez *et al.*, 2001). *Eudrilus eugeniae* outperformed *Eisenia fetida* at 25°C (77°F) in tests using cattle manure as fuel, according to Dominguez *et al.*,

(2001). This implies that vermicomposting systems in tropical regions are the perfect fit for this species.

According to Jiang *et al.*, (2018), earthworms are important detritivores that are necessary for the breakdown of organic matter that is decaying. African nightcrawlers, red wigglers, and common earthworms are examples of trichomes, or animals that consume decaying plant and animal matter. However, different kinds of earthworms have different eating niches. For example, composting earthworms consume manure and decaying plant matter that is towards the beginning of the decomposition process, whereas epigeic earthworms live under leaf litter and rotting logs and consume partially degraded organic waste. Thus, the ideal earthworm for the duty as a detritivore in an organic composting system may vary based on the specific type of organic matter being composted.

2.10 Activity pattern of earthworm species

The activity pattern of earthworm species in an organic composting system is a topic of interest in the field of soil science and agriculture. Several studies have investigated the role of earthworms in composting and their impact on soil microbiota and nutrient cycling.

Earthworms play a crucial role in organic matter decomposition and nutrient cycling in composting systems. Research has shown that earthworms can significantly impact soil microbiota, nutrient content, and microbial community functioning in organic composting systems. (Tagliabue, F. *et al.*2023) The activity patterns of earthworm species, such as burrowing habits and feeding behaviour, can influence the decomposition rates and the quality of vermicompost, which is a nutrient-rich organic fertilizer produced through earthworm activity (Bolger, T. *et al.*2006)

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental Setup

This study is conducted at (coordinate of 5.7443° N, 101.8635° E) employing models of soil pedon to allow observations of earthworm activity pattern in a controlled experimental setup.

Previously, Shekari *et al.*, (2020) examined the effects of different soil types on the burrowing habits of earthworms (*Eisenia fetida*) using enclosures made of clear acrylic but in this study, we improvised the setup using clear perspex plastic to put all the composting materials and earthworms. Perspex is clearer and allow recording and observing the earthworm behaviour easily.

Based on research conducted by Nor Azazi Zakaria *et al.*, in 2016, we modified a little bit in this study, we used perspex plastic measured 5 centimetres in height for soil, 5 centimetres in height for tea ground and paper, food waste and dried leaves. We also used 5 cm in width and 20 centimetres in length. We make 2 perspex boxes and include one earthworm species in each perspex box as shown in the figure below:



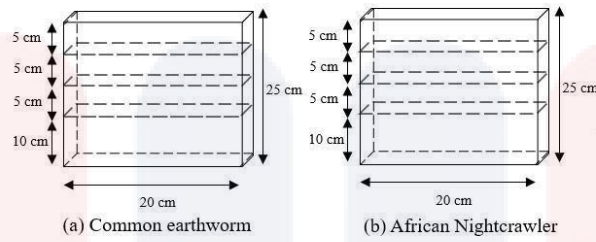


Figure 3.0: Models of soil enclosure containing (a) *Lumbricus terrestris* and (b) *eudrilus eugeniae*

Each box contained about 20 earthworms based on their species in the designated box. First box contained (a) common earthworm (*Lumbricus terrestris*), while second box contained (b) African Nightcrawler (*eudrilus eugeniae*).



Figure 3.1: Models of soil enclosure in 3D image.

Apart from that, for method 2, which is to measure the effectiveness of each species, we also designed 3 boxes and two boxes contained earthworm species and one box not contained earthworm, as shown below:

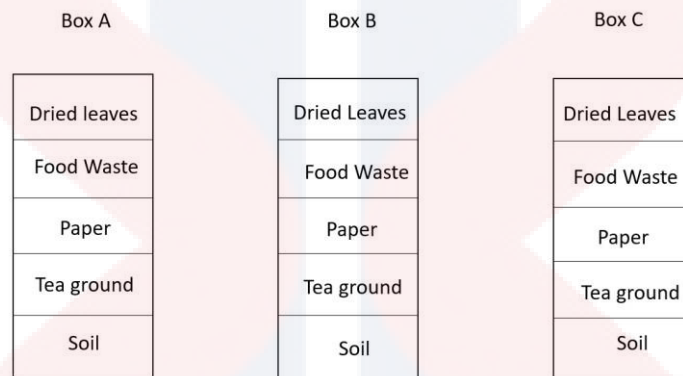


Figure 3.2: Models of soil box containing a) that contained common earthworm b) that contained African nightcrawler c) contained no type of earthworms (Control).

3.1.1 Soil medium

In this study, we used 5 types of composting substrate which are soil, tea ground, food waste, paper and dried leaves. As for the substrate, we are focusing on using kitchen waste, agriculture waste, and plant material to conduct this experiment (Yingyuenyong, M. 2012). Each layer contained about 200-300g depends on what kind of types of composting substrate. This means that every box weigh about 1000g. Soil located at the bottom of the layer and tea ground located at the second layer of the box, followed by paper in the third layer and food waste in the fourth and dried leaves in fifth layers.

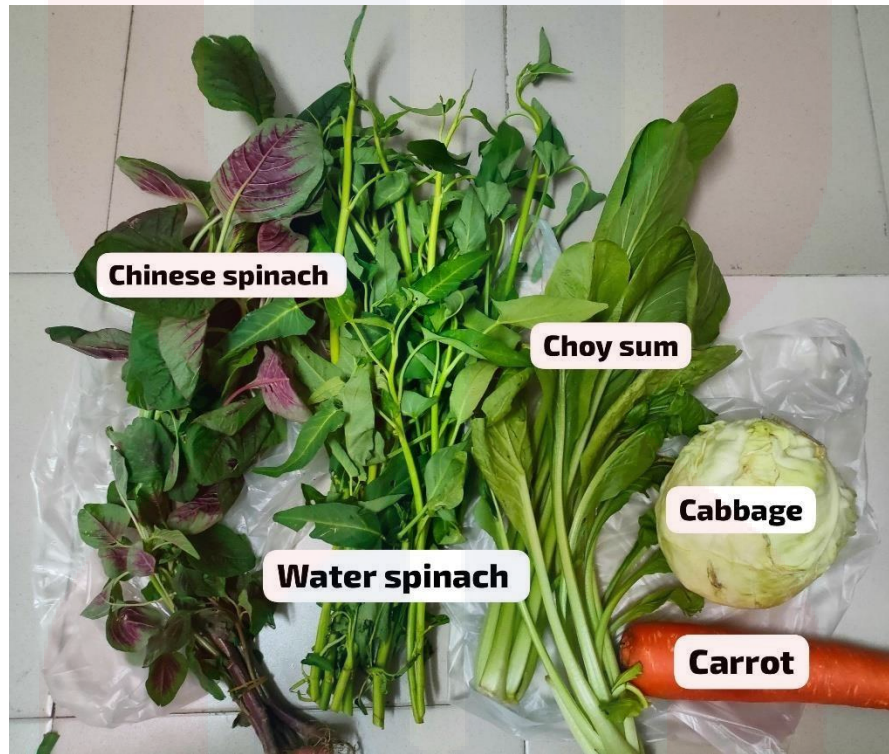


Figure 3.4: The materials used in food waste.

3.1.2 Earthworm spp.

In this experiment, we used two different types of earthworms which are *Lumbricus terrestris* (Common earthworm) and *Eudrilus eugeniae* (African nightcrawler). All these earthworms can be found or purchased in Malaysia. Each box contained 20 earthworms. These species were chosen because their abilities in composting substrate differ between each species. As for the second methods, 100 earthworms are used in 2 boxes, which are box 1 and box 2.

3.2 Assessing the activity pattern and feeding behavior of two different species – *Lumbricus terrestris* (Common earthworm), and *Eudrilus eugeniae* (African nightcrawler)

In this study, we discuss in depth the feeding duration and feeding location of these 2 species. Measuring the length of time that earthworms spend feeding and tracking where they eat within the composting system are two ways that this study will evaluate earthworm activity pattern. Feeding duration is determined by the amount of time earthworms spend in a particular area of the soil enclosure and the time of day that they are most active.

3.2.1 Feeding Duration and feeding locations.

In this study, we observe the feeding duration of earthworms in designated time and time they are most active. We will determine the feeding location of earthworm species based on their location in the soil enclosure whether in the upper area or bottom area. It will show the most preferable location for earthworm species to feed.

We will also determine how long the time needed to completely compose the organic material and determine whether the earthworms are diurnal or nocturnal eaters. Based on table 1, we can determine what time is most preferable for the earthworm to be active. We can classify them as diurnal and nocturnal eaters.

3.3 Assessing the most effective earthworm as detritivore in organic composting system.

By observing the feeding rates and preferences of the species in response to these varied organic materials frequently found in agricultural waste from Malaysia, the study provided significant insights into the efficacy of *Lumbricus terrestris*, and *eudrilus eugeniae* within composting systems under the unique tropical climate of Malaysia. For the experimental investigation, the composting system will be stored at temperature of 25 °C and a relative humidity of 80% was utilized (Viljoen & Reinecke in press). The most effective earthworms will be observed.

3.4 Data Analysis

For objective 1, Chi-square test is used to test for significant differences between frequency data on the activity pattern of *Lumbricus terrestris* (Common earthworm) and *Eudrilus eugeniae* (African Nightcrawler) in organic composting system.

$$x^2 = \sum \frac{(f_o - f_e)^2}{f_e} \quad (3.1)$$

Where;

x^2 = Chi square

Σ = Sum

f = frequency

H_0 = Null hypothesis

H_1 = Alternative hypothesis

f_0 = Observed frequency

f_e = Expected frequency

To draw the conclusion for Chi-square test, there will be two (2) indication of Chi-square test, if,

$\chi^2 >$ Critical value, then we reject the H_0

$\chi^2 <$ Critical value, then we accept the H_0

The hypothesis of this study will be:

H_0 = There is no significant difference in the activity patterns of the common earthworms and African night crawlers

H_1 = There is a significant difference in the activity patterns of the common earthworms and African night crawlers.

For objective 2, to determine the most effective earthworm as detritivore in organic composting system, comparison is made based on the change in compost height after seven (7) days. The change is recorded using the volume of each soil enclosure in every day.

$$\text{Volume} = L \times W \times H \quad (3.2)$$

Using the volume of each soil enclosure, decomposition rate (%) can be calculated. Decomposition rate % is estimated by $(\text{Day 7} - \text{Day 1}) / \text{Day 1} \times 100$

$$\text{Decomposition Rate (\%)} = \frac{\text{Day 7} - \text{Day 1}}{\text{Day 1}} \times 100 \quad (3.3)$$

CHAPTER 4

RESULT AND DISCUSSION

4.1 Activity Pattern of *Lumbricus terrestris* (Common earthworm) and *Eudrilus eugeniae* (African Night Crawler) in soil enclosures

The activity pattern of *Lumbricus terrestris* (common earthworm) and *Eudrilus eugeniae* (African nightcrawler) in soil enclosure was observed for a week (7 days consecutively) starting from 12th of April until 18th of April (Table 4.1; Figure 4.1).

Table 4.1: Total daily frequency of activity pattern between *Lumbricus terrestris* (common earthworm) and *Eudrilus eugeniae* (African nightcrawler) for a week.

Activity pattern	Frequency, <i>f</i>															
	<i>L.terrestris</i>								<i>E.eugeniae</i>							
	Days								Days							
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total
Burrowing	0	2	2	2	0	2	0	8	1	1	1	2	1	2	2	10
Surface Locomotion	0	1	1	0	0	0	0	2	0	1	0	2	1	0	0	4
Resting	2	1	2	3	2	2	2	14	3	2	2	2	1	2	2	14
Navigating the Composting Layer	2	1	0	1	2	2	0	8	1	0	0	1	2	1	2	7
Vertical Movement	2	2	2	2	2	2	0	9	1	1	2	1	2	2	2	11
Horizontal Movement	2	1	0	0	1	1	2	5	0	1	0	0	1	1	2	5
Total (Σf)								46								51

Overall, the total frequency across all activity patterns for *Lumbricus terrestris* is 46 while for *Eudrilus eugeniae* is 51 (Table 4.1). This indicated that the activity pattern for *Eudrilus eugeniae* is higher as compared to *Lumbricus terrestris*. When it comes to vermicomposting, the African Nightcrawler is incredibly successful in rapidly and thoroughly decomposing organic materials. Its capacity to digest substantial amounts of organic waste and enable a steady process of worms to process compost, remarks their efficiency in degrading the materials (Hazra *et al.*, 2018).

Due to their faster metabolism and increased level of activity, African Nightcrawlers require more frequent feedings. They have a daily feeding capacity of up to 1.5 times their body weight, which is more than the common earthworm's 1:1 ratio. This is the reason why the activity pattern of *Eudrilus eugeniae* are more frequent as compared to *Lumbricus terrestris*.(Kyle & Jen Strickland, 2018).

4.1.1 Daily observation of activity pattern of *Lumbricus terrestris* and *Eudrilus eugeniae*

In terms of the daily activity pattern, there is significant change between *Lumbricus terrestris* and *Eudrilus eugeniae* in the observation. *Lumbricus terrestris* had a wider range in location of activity pattern that includes burrowing (f= 8), navigating compost layer (f= 8) and vertical movement (f= 9) as compared to *Eudrilus eugeniae* had lower range in location of activity pattern include burrowing (f = 10), navigating the compost layer (f = 7), and vertical movement (f = 11) as shown in (Figure 4.1). This is prominent between day 3 and 5 during observation. We assume that this happens because of *Lumbricus terrestris*, is a topsoil dweller that favors smaller organic residue particles integrated into the soil while *Eudrilus eugeniae* are epigeic earthworms that flourish in compost or leaf litter and are ideally suited for

vermicomposting organic waste that mainly the reason why *Lumbricus terrestris* spend most of the time in the soil layers (Duiker, S. W., & Stehouwer, R. 2013) while *Eudrilus eugeniae* spend most of the time in first and second layers of soil enclosure. Apart from that, the differences between the locations of the earthworms are also related to the type of the earthworms themselves. *Lumbricus. terrestris* is known as anecic earthworm which means that they burrow deep down into the soil layer while *Eudrilus eugeniae* is known as epigeic earthworm which means that they only inhabits and feed in the surface of the soil or organic layer (Astaykina *et al.*, 2022).

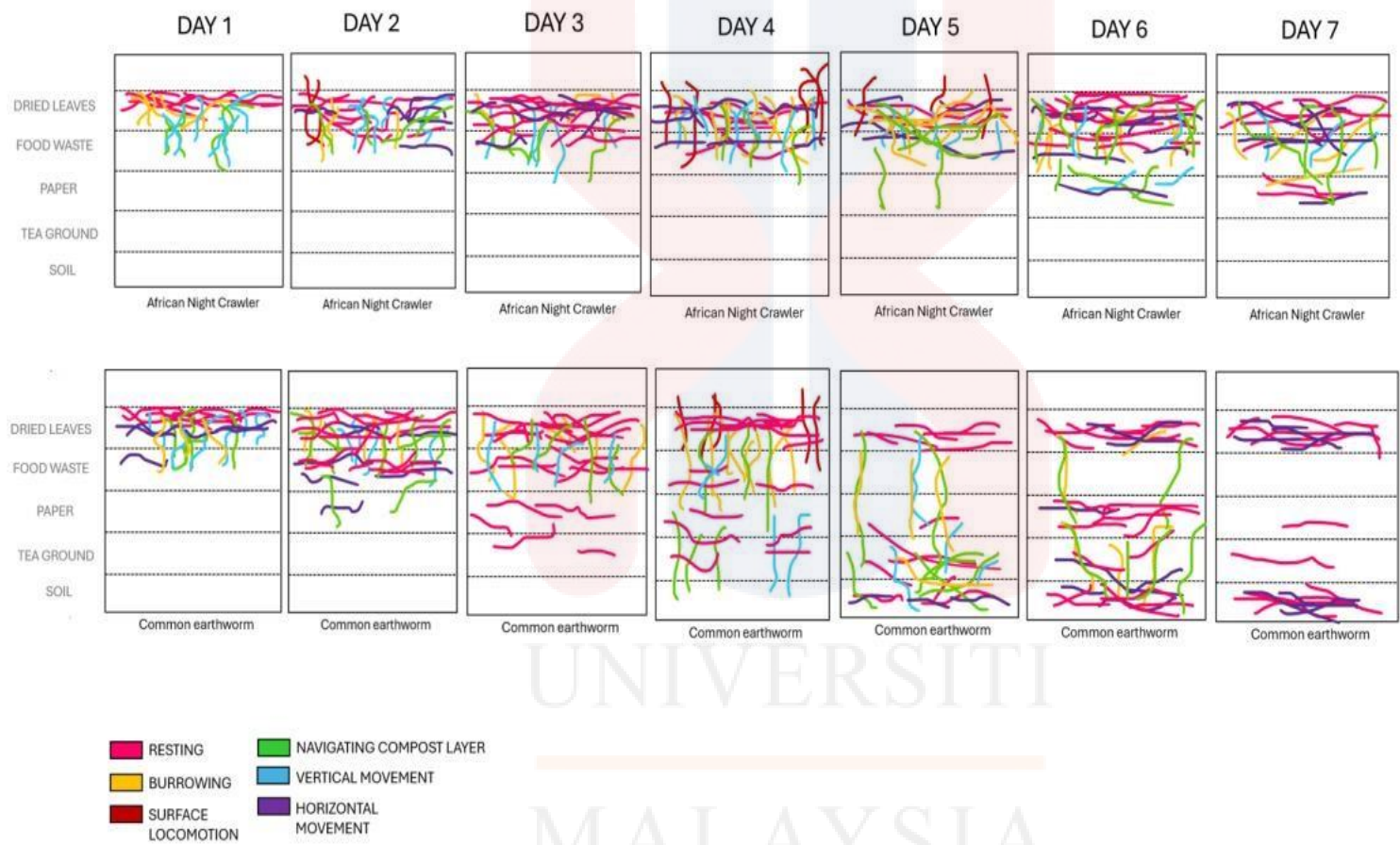


Figure 4.1: The result of observation of activity pattern of earthworms in 7 days.

4.1.2 Activity Pattern of *Eudrilus Eugeniae* and *Lumbricus Terrestris* between 4 different period and their frequency.

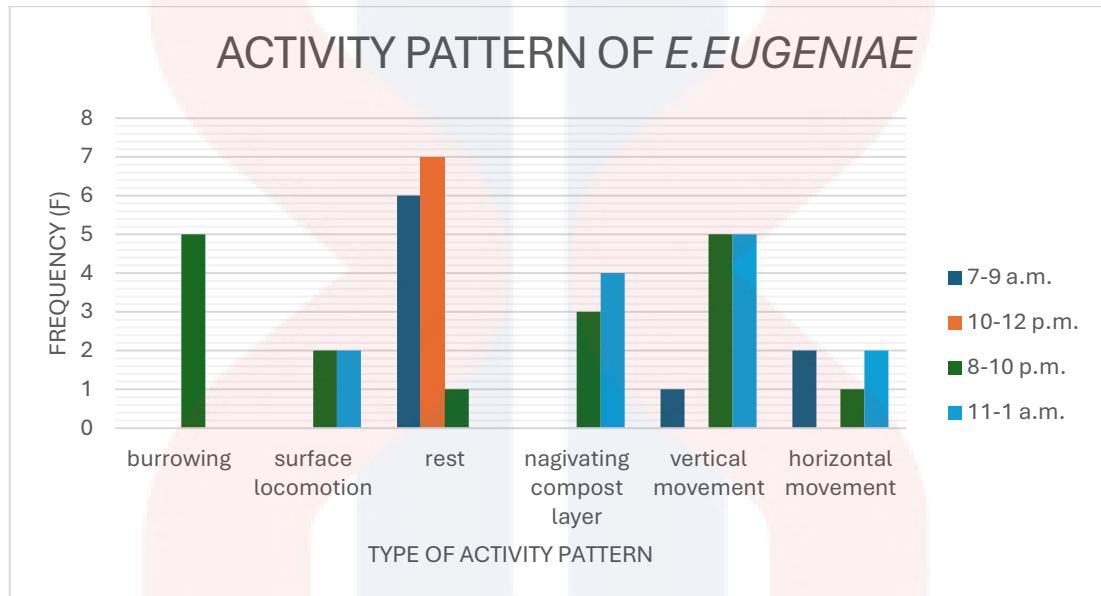


Figure 4.2: Total of activity pattern of *Eudrilus eugeniae* (African night crawler) in their designated time for one (1) week.

Based on the results in figure 4.2, we can see the recorded pattern of earthworm spp. in the graph based on the designated time (Figure 4.2). The graph shows the activity pattern of African Nightcrawler (ANC) for one week. During 7 to 9 a.m, there is no movement recorded for burrowing, surface locomotion, and navigating compost layer. Most of the earthworms are resting and some movement is recorded for vertical and horizontal movement during 7 to 9 am. Its shows how minimal their activity during that time. During 10-12 p.m., all earthworms are resting as no activity recorded for the rest of activity pattern.

Moving to the night-time, their activity patterns increase significantly for all the activity patterns except for resting for 8-10 p.m... The highest activity pattern recorded are burrowing and vertical movement (5 times). During 11-1 a.m., there is no significant difference between 11-1 a.m. and 8-10 p.m.

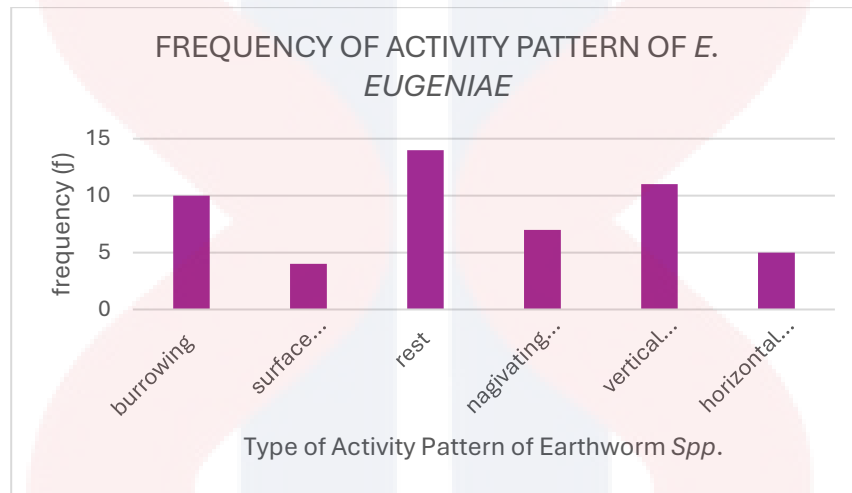


Figure 4.3: The frequency of activity pattern of *Eudrilus eugeniae* for one (1) week.

Figure 4.3 shows the frequency of activity pattern of *Eudrilus eugeniae* for one (1) week. We can see that the highest frequency recorded is resting (14). This is because during daytime, there is minimal movement of them because they are known as nocturnal species (Domínguez, J., & Edwards, C. A. 2011) which means they are most active during nighttime. The lowest frequency is surface locomotion at four (4) occurrences. Surface locomotion is set as an indicator for the soil enclosure because, earthworms have a tendency to abandon their homes if the surrounding is not favourable (Neupane, 2023). The data proved that the soil enclosure is suitable place for the earthworms to inhabit because the least occurrence. Earthworms are sensitive to various environmental factors, including soil characteristics, moisture content, and

temperature. They may emerge from their burrows and go to the soil's surface in search of better circumstances if they are unfavourable (Neupane, 2023)

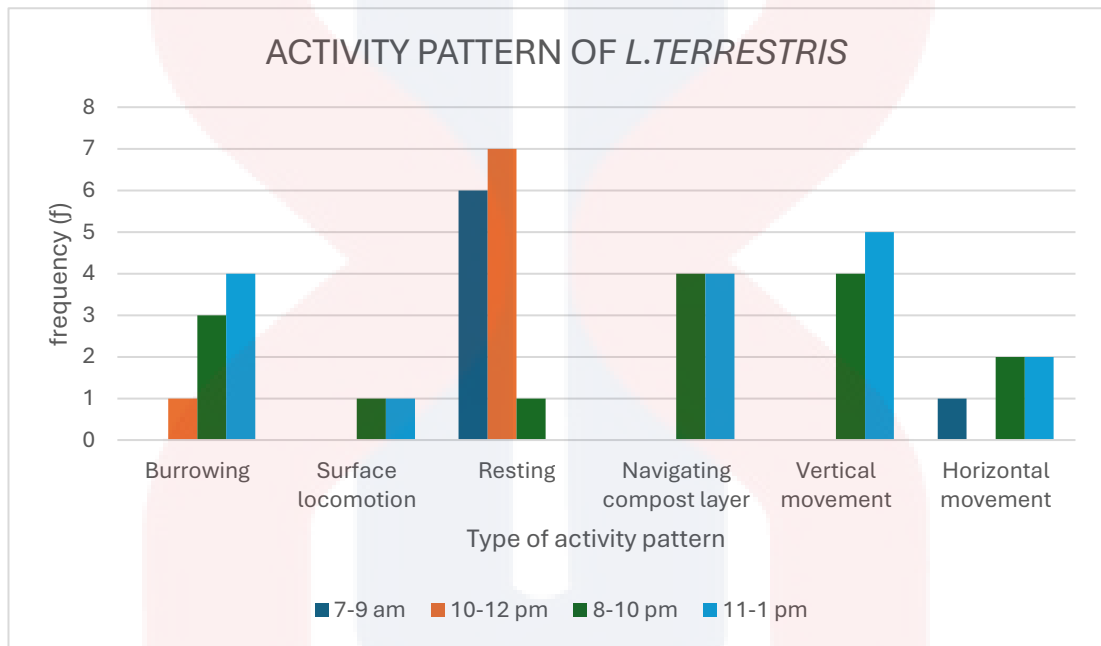


Figure 4.4: Total of activity pattern of *Lumbricus terrestris* (Common Earthworm) for one (1) week.

Based on the results in figure 4.4, we can see the activity pattern of Common earthworm for one week. During 7 to 9 a.m., there is no movement recorded except for horizontal movement. Most of the earthworms are resting. Its shows how minimal their activity during 7 to 9 a.m... During 10 to 12 p.m., one activity pattern recorded which is burrowing, and the others are still resting.

Moving to the night-time, their activity patterns also increasing for all the activity patterns except for resting for 8 to 10 p.m. The highest activity pattern recorded are navigating composting layer and vertical movement (4 times). During 11 to 1 a.m.,

there is no significant difference between 11 to 1 a.m. and 8 to 10 p.m... the highest record during that time is vertical movement (5 times).

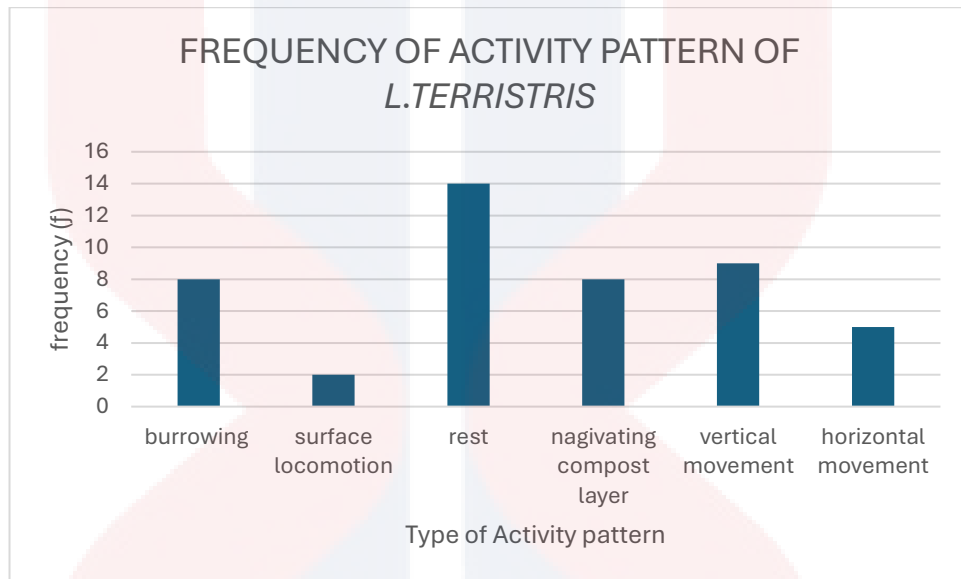


Figure 4.5: The frequency of activity pattern of Common Earthworm for one (1) week.

Figure 4.5 shows the frequency of activity pattern of *Lumbricus terrestris* for one (1) week. We can see that the highest frequency recorded is resting (14). It's the same as *Eudrilus eugeniae* because both of them is nocturnal eaters (Domínguez, J., & Edwards, C. A. 2011) which means they are most active during nighttime. The lowest frequency also the same as *Eudrilus eugeniae*, which is surface locomotion at four (4) occurrences.

4.1.2 Summarization of Chi-square test comparison (Activity Pattern of both species)

H_0 = There is no significant difference in the activity patterns of the common earthworms and African night crawlers

H_1 = There is a significant difference in the activity patterns of the common earthworms and African night crawlers.

For the activity patterns of both earthworm species, statistical analysis shows that there are no significant differences between activity patterns of both earthworms (Table 4.2). The Chi-square is 0.900 (Table 4.2) which is lower than critical value (11.070) (Table 4.2). The P-value of this test is 0.970, which are greater than the significance level (0.05). The possibility of false positives rises when comparing different activity patterns. The many comparisons of activity pattern could be the reason why it is statistically not significant. (Ruiz *et al.*, 2021). As a result, we failed to reject the H_0 which means, there is no significant difference between activity patterns of earthworms and their species.

Table 4.2: Chi-square Test comparison of six activity patterns

Table 4.2: Chi- square Test	
Significance Level	0.05
Chi-square	0.900
Degree of Freedom	5
P-value	0.970
Critical value	11.070

4.1.3 Summarization Chi square test comparison (most preferred location of earthworms)

H_0 = There is no significant difference between location of earthworms *spp.*

H_1 = There is significant difference between location of earthworms *spp.*

For the location of both earthworm species, statistical analysis shows that there are significant differences between the location of both earthworms (Table 4.3). The Chi-square is 14.391 (Table 4.3) which is greater than critical value (9.488) (Table 4.3). The P-value of this test is 0.006, which are lower than the significance level (0.05). As a result, we have to reject the H_0 which means, there is a significant difference between location of earthworms and their species. Based on the figure 4.1, it clearly shows that there are significant differences between the location of the earthworm's species.

Table 4.3: Chi-square test comparison location earthworms *spp.* in five types of organic materials

Table 4.3: Chi- square Test	
Significance Level	0.05
Chi-square	14.391
Degree of Freedom	4
P-value	0.006
Critical value	9.488

4.2 Effectiveness of earthworms *spp.* in decomposing organic waste

Compost system	Volume of compost cm ³							Decomposition rate (%)
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	
<i>Lumbricus terrestris</i>	2420	1936	1815	1694	1452	1331	1089	55%
<i>Eudrilus eugeniae</i>	2420	1815	1694	1573	1331	1210	847	65%
No earthworm (control)	2420	2420	2299	2178	2178	2057	2057	15%

*Decomposition rate % is estimated by $(\text{Day 7} - \text{Day 1}) / \text{Day 1} \times 100$

Table 4.2 Decomposition rate (%) of organic composting system

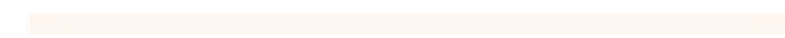
Earthworm species' efficacy was noted in table 4.2 and figure 4.6. From it, we could observe that *Eudrilus eugeniae* has the highest rate of decomposition (65%), followed by *Lumbricus terrestris* (55%) and no earthworm (15%). It demonstrates that the best organism for breaking down the organic compounds in the soil enclosure is *Eudrilus eugeniae*. Research has demonstrated that *Eudrilus eugeniae* can eat a wide variety of organic materials. According to Karnwal and Kumar (2019), this explains why *Eudrilus eugeniae* breaks down organic waste more efficiently than *Lumbricus terrestris*.

For the no earthworm soil enclosure (control), there is a small difference in their volume even though there is no earthworm included (Table 4.2) (Figure 4.6). This is because soil can settle fast in an enclosure once it is first laid, particularly if it has recently been disturbed. Days may pass during this initial settling as gravity and other

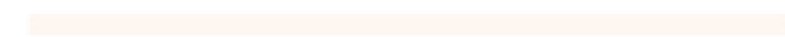
natural packing forces work. The process of compaction causes the gaps between soil particles to shrink, which lowers the volume of the soil (Dexter, 2004).



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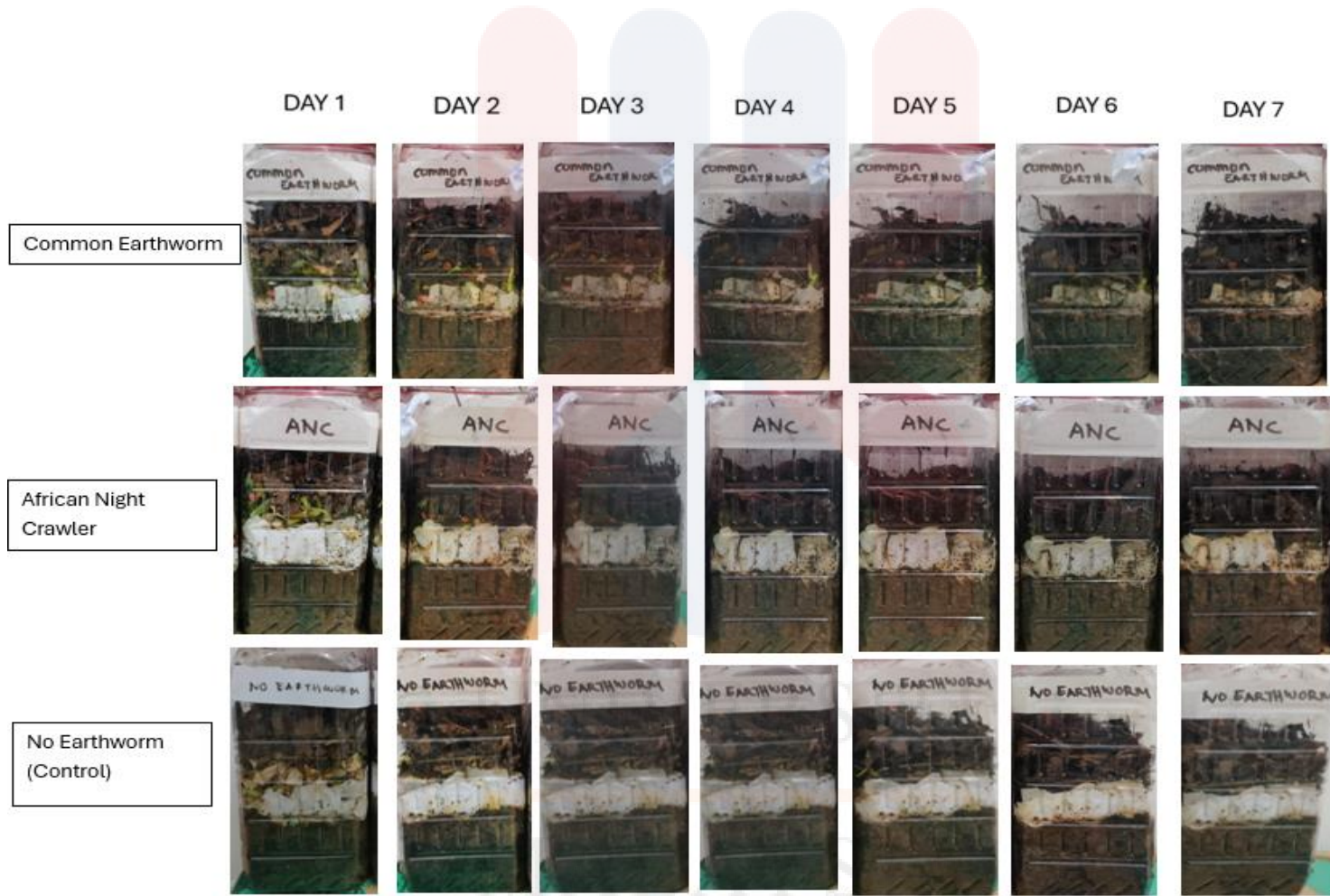


Figure 4.6: The effectiveness of earthworms *spp.*

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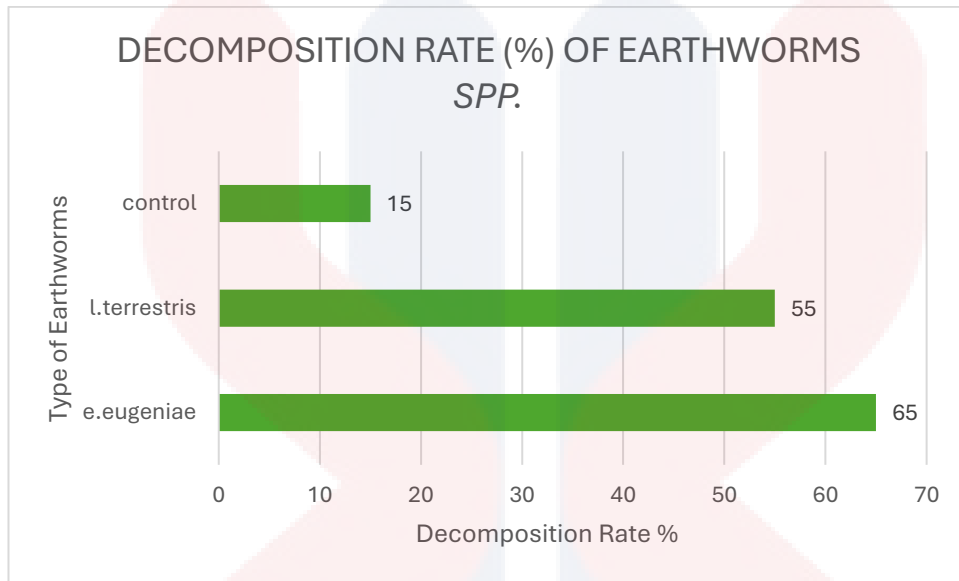


Figure 4.7: The decomposition rate (%) of earthworms spp.

Figure 4.7 shows the decomposition rate (%) of earthworm's species. The highest decomposition rate (%) is *Eudrilus eugeniae* at 65%, outperforming the *Lumbricus terrestris* at 55%. The lowest decomposition rate (%) is the control which at 15% only.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The purpose of the study was to look into how two species of earthworms—the African nightcrawler, *Eudrilus eugeniae*, and the standard earthworm, *Lumbricus terrestris*—behave in organic composting systems. The findings demonstrate that the two species have different patterns of activity, with *Eudrilus eugeniae* showing more efficiency in detritivore and the breakdown of organic materials.

For objective 1, we could see that the two earthworms spp. has their own activity pattern and differ between the two of it. *Eudrilus eugeniae* is more preferred in food waste while *Lumbricus terrestris* is more preferred in soil.

For objective 2, *Eudrilus eugeniae* has shown a greater capacity for consuming and decomposing organic materials, especially harmful substances, which is necessary for effective composting. This is explained by its special qualities, which include its fast rate of reproduction, which enables it to process bigger volumes of organic materials more effectively, and its capacity to flourish in a wide variety of temperatures.

Lumbricus terrestris, on the other hand, shown a less capacity to break down organic waste, probably as a result of its slower rate of reproduction and affinity for colder climates.

Eudrilus eugeniae is the most efficient earthworm species as a detritivore in organic composting systems, according to their data. It is the perfect choice for vermicomposting applications because of its capacity to effectively decompose

organic matter and eliminate harmful chemicals. The findings of this study emphasize how crucial it is to take into account the unique traits and inclinations of various earthworm species when developing composting systems.

5.2 Recommendation

Due to *Eudrilus eugeniae*'s better effectiveness in detritivory and organic material breakdown, it is recommended to optimize organic composting systems based on the study's findings. This species is very useful for processing vast amounts of organic waste, including hazardous materials, because of its high rate of reproduction and capacity to flourish in a variety of temperatures. The study shows that *Lumbricus terrestris* is less effective in decomposing organic waste because of its slower reproduction rate and predilection for cooler regions, even if using multiple species of earthworms may seem advantageous. As a result, when it comes to mixed-species composting, certain composting objectives and environmental circumstances should be carefully considered.

In order to maintain the ideal circumstances for *Eudrilus eugeniae*, including the right pH, moisture content, and temperature ranges to support the species' reproductive and detritivorial activities, composting systems should be built to take use of its distinctive characteristics. To maintain high composting efficiency, these conditions must be regularly monitored and adjusted. The long-term effects of utilizing *Eudrilus eugeniae* in many composting scenarios, including its interactions with various organic material types and its general influence on soil health and quality, should be investigated further.

Composting efficiency can also be increased by teaching composters about the advantages of utilizing *Eudrilus eugeniae* and how to keep the right conditions for this species. In order to encourage the adoption of more environmentally friendly and efficient composting methods, policymakers should also be urged to support the use of *Eudrilus eugeniae* in composting programs through grants, subsidies, and other incentives. Composting systems can be modified for improved soil health and enhanced organic waste decomposition by concentrating on *Eudrilus eugeniae*'s capabilities and taking into account the unique requirements of various earthworm species.

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APPENDIX A

Appendix A.1: Example of data sheet to record earthworms' behaviour for enclosure 1.

Soil enclosure 1

	Activity Pattern	Burrowing	Surface Locomotion	Resting	Navigating Compost Layer	Vertical Movement	Horizontal movement
Diurnal	7.00 a.m. – 9.00 a.m						
	10.00 a.m. – 12.00 p.m.						
Nocturnal	8.00 p.m – 10.00 p.m.						
	11.00 p.m – 1.00 a.m.						

Appendix A.2 : Example of data sheet to record earthworms' behavior for soil enclosure 2.

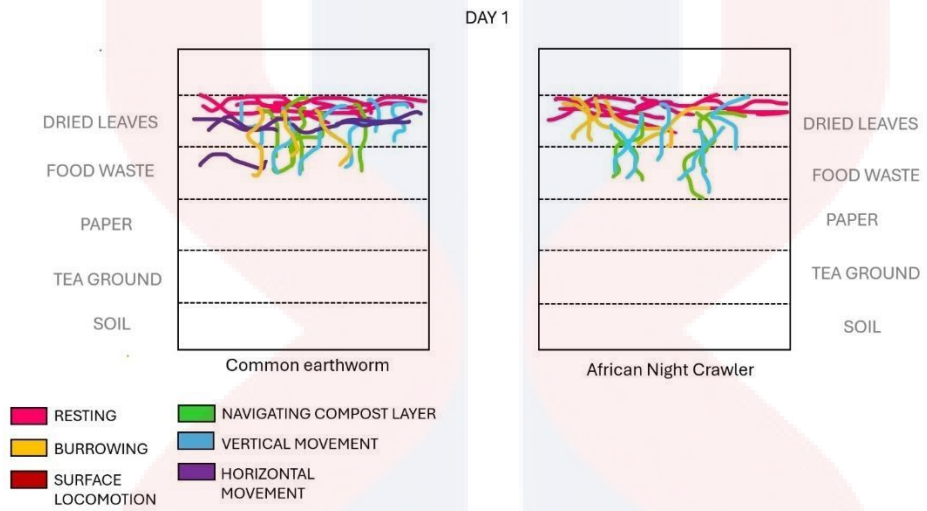
Soil enclosure 2

	Activity Pattern	Burrowing	Surface Locomotion	Resting	Navigating Compost Layer	Vertical Movement	Horizontal movement
Diurnal	7.00 a.m. – 9.00 a.m						
	10.00 a.m. – 12.00 p.m.						
Nocturnal	8.00 p.m – 10.00 p.m.						
	11.00 p.m – 1.00 a.m.						

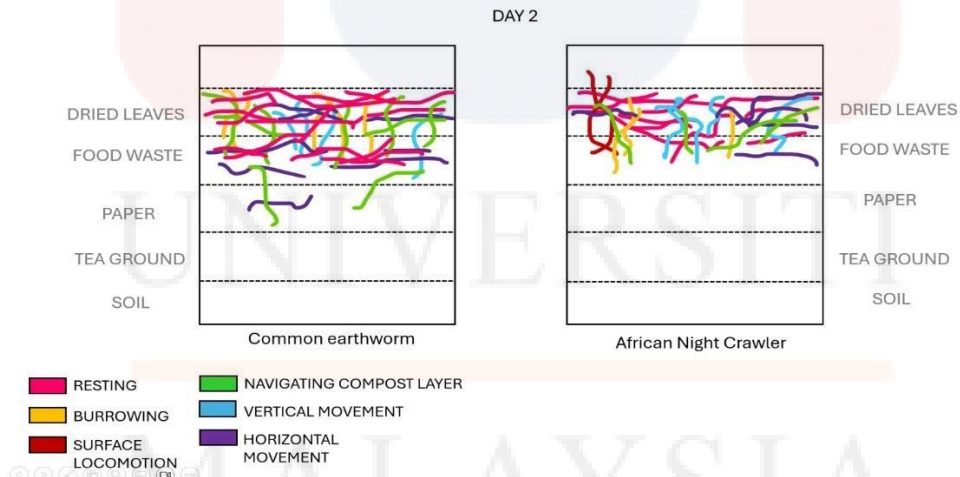


APPENDIX B

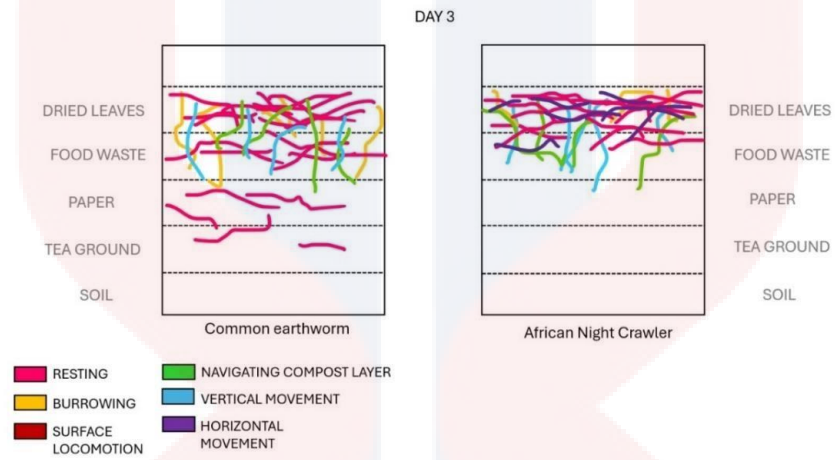
Appendix B.1: Result of activity pattern of earthworm *spp.* day 1



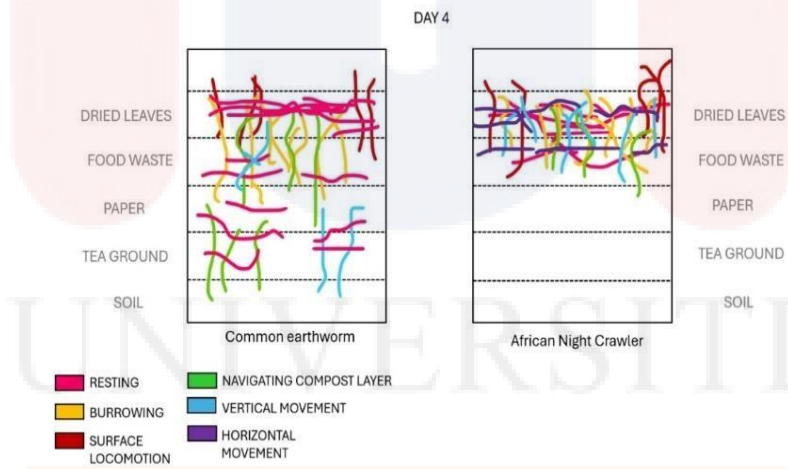
Appendix B.2: Result of activity pattern of earthworm *spp.* day 2



Appendix B.3: Result of activity pattern of earthworm *spp.* day 3



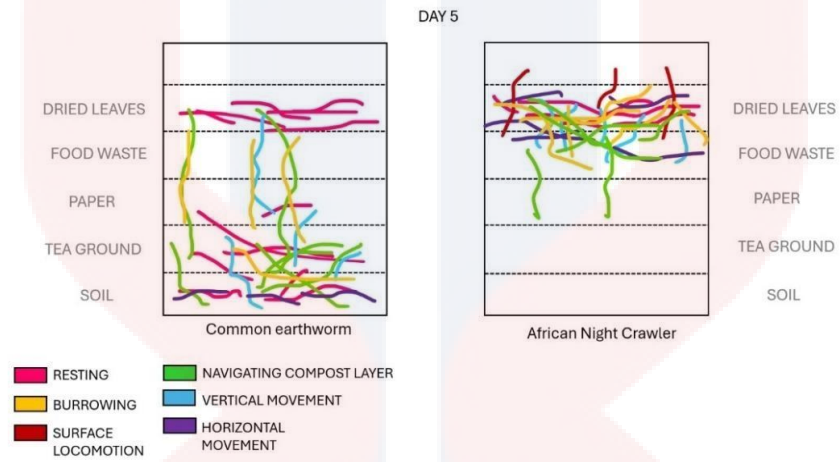
Appendix B.4: Result of activity pattern of earthworm *spp.* day 4



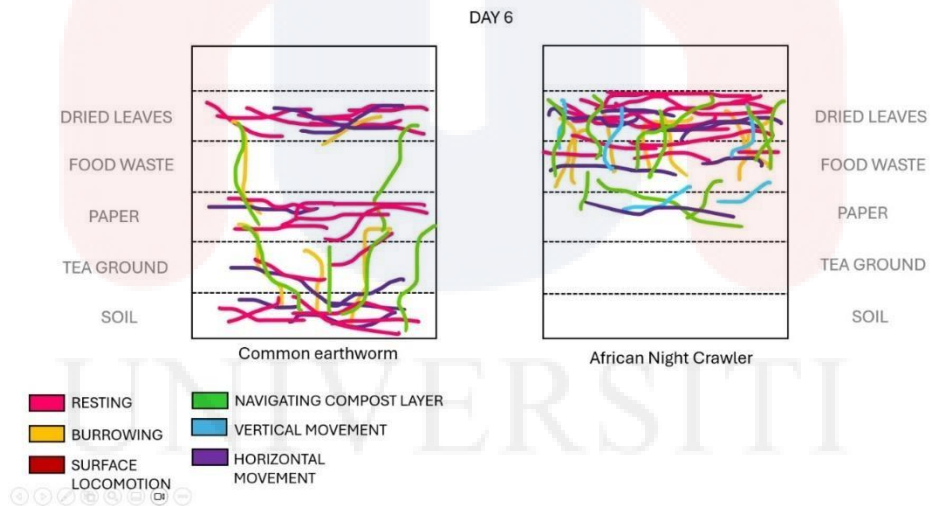
MALAYSIA

KELANTAN

Appendix B.5: Result of activity pattern of earthworm *spp.* day 5



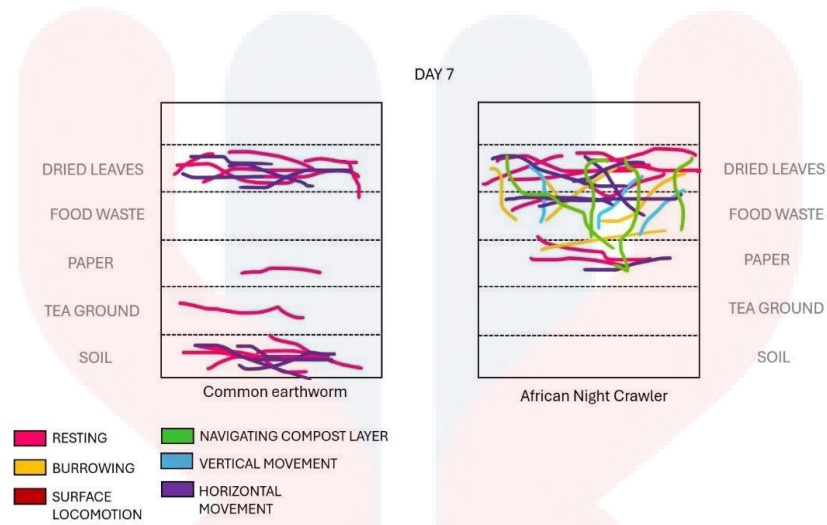
Appendix B.6: Result of activity pattern of earthworm *spp.* day 6



MALAYSIA

KELANTAN

Appendix B.7: Result of activity pattern of earthworm *spp.* day 7



Appendix B.8: Result of effectiveness of earthworms *spp.* day 1



Appendix B.9: Result of effectiveness of earthworms *spp.* day 2



Appendix B.10: Result of effectiveness of earthworms *spp.* day 3



Appendix B.11 Result of effectiveness of earthworms *spp.* day 4



Appendix B.12: Result of effectiveness of earthworms *spp.* day 5



Appendix B.13: Result of effectiveness of earthworms *spp.* day 6



Appendix B.14: Result of effectiveness of earthworms *spp.* day 7

