CIRAWA Agroecological Solutions for Resilient Farming in West Africa

Vermicomposting Technical Manual

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Layout and graphic design by REVOLVE.

Summary

Photo: Earthworms on soil for organic fertilizer farming by Kckate16 for Envato

Introduction

Vermicomposting is the process of transforming organic waste through the joint action of earthworms and microorganisms.

The final product obtained is referred to as *vermicompost, worm humus, worm castings*, or variations thereof. It is considered one of the most valuable organic fertilizers on the market.

There are more than 8,000 species of earthworms worldwide, but only 6 to 8 are commonly used in vermicomposting. Among these, *Eisenia fetida* and *Eisenia andrei* are the most widely employed species, while *Eudrilus eugeniae* is best adapted to subtropical climates. The selection of these specific species is mainly due to their high reproductive rates and voracious feeding behaviour, which allows for the maximization of vermicompost production. Nonetheless, all earthworms are capable of transforming decomposing organic matter, albeit at much slower rates.

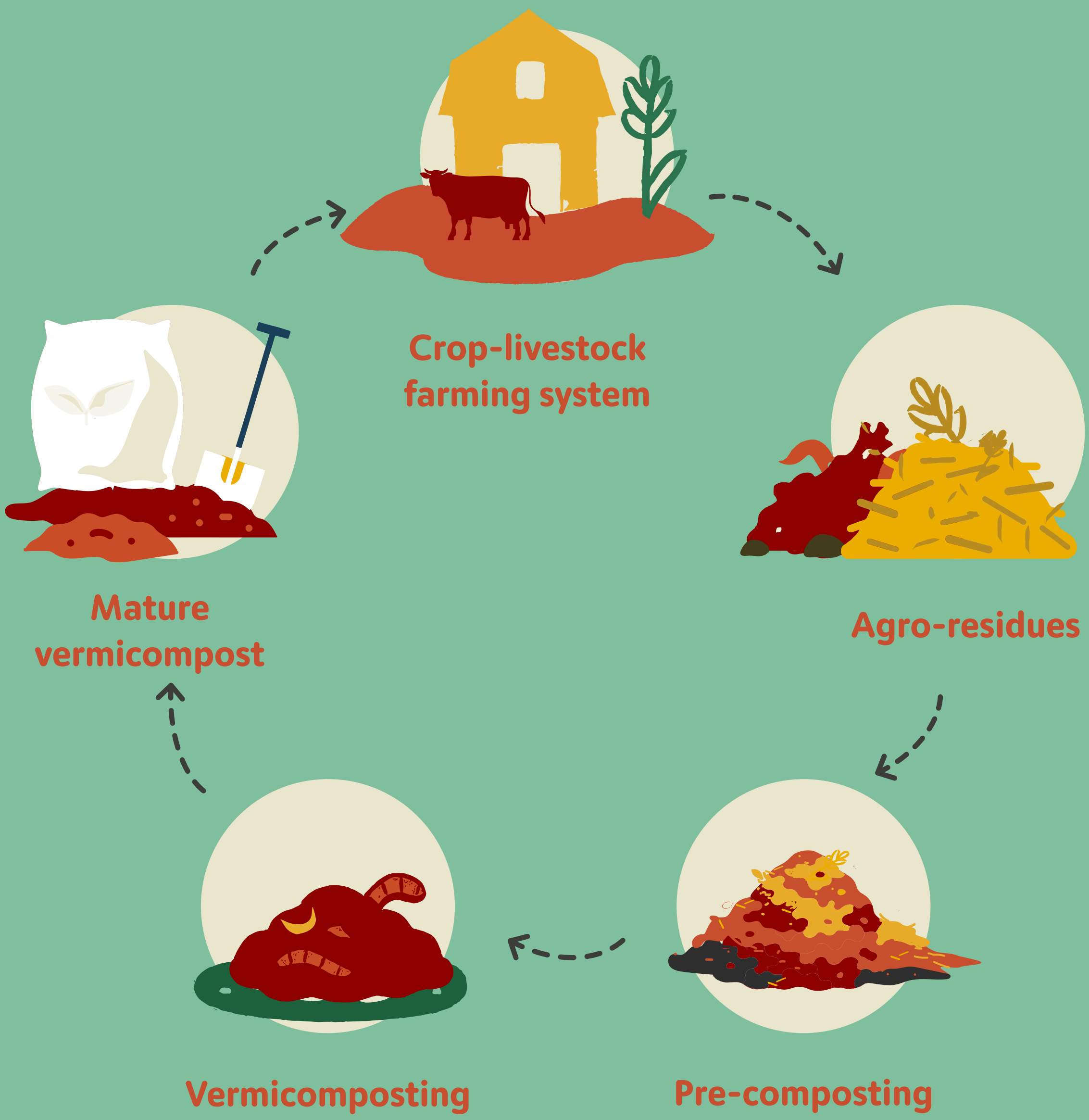


Figure 1: The vermicomposting cycle

2. Characteristics of earthworms

Morphology

- *Eisenia fetida* and *Eisenia andrei* are small earthworm species (less than 10 cm in length), whereas *Eudrilus eugeniae* is among the largest used in vermiculture, with an average length of approximately 20 cm.
- Their **bodies** are **segmented into rings** whose mobility facilitates locomotion.
- In adulthood, they develop a specialized ring near the anterior end, called the **clitellum**, which is a marker of sexual maturity and plays a key role in reproduction and cocoon formation (sexual structures).
- Earthworms possess a mouth but **lack teeth**, a characteristic that determines their specific dietary requirements.
- Earthworms are **incomplete hermaphrodites**—they possess both male and female reproductive organs but are not capable of self-fertilization.

Life cycle

1. During mating, two earthworms coil around each other and remain in this position for approximately 15 minutes, during which they exchange reproductive fluids, enabling mutual fertilization.
2. A few days later (typically between 3 and 7 days, depending on environmental conditions), each worm deposits a cocoon.

3. Between 2 and 9 juvenile worms (commonly 3 to 4) emerge from each cocoon after 15 to 20 days. The hatchlings begin feeding on the same substrate as the adults.
4. After 2 to 3 months, they develop a clitellum, indicating sexual maturity and the beginning of a new reproductive cycle (Figure 2).

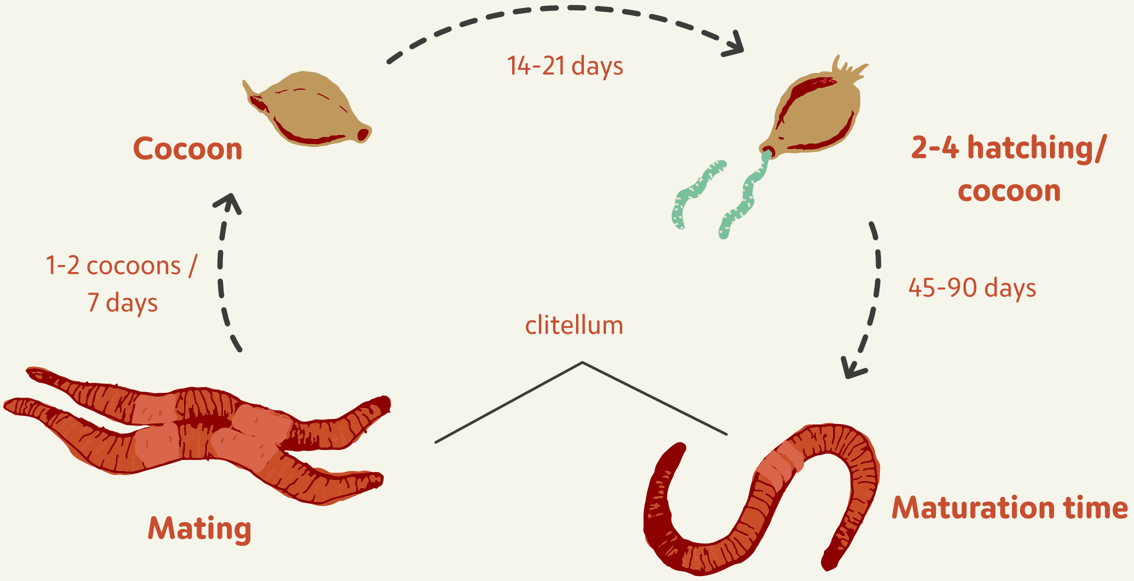


Figure 2: Life Cycle of *Eiseina fetida*

Earthworm Ethology

The earthworm species used in vermicomposting processes are capable of living in soil environments but are significantly better adapted to organic matter beds, which makes them highly efficient decomposers. These are epigeic worms, meaning they inhabit the surface layer of substrates, which exposes them to greater environmental risks. As a result of evolutionary pressures, these species have developed high reproductive rates and produce cocoons that are highly resistant to adverse conditions.

3 . Requirements of earthworms

Optimal conditions for growth and development

Their ideal habitat consists of **decomposing organic matter beds** with:

- a **moisture content** of approximately **80%**. Although earthworms can survive under drier conditions, their decomposition activity slows considerably.
- The optimal **temperature** range for their development lies **between 15°C and 25°C**. Reproduction ceases when temperatures fall below 7°C, and mortality occurs below 3°C and above 35°C.
- Regarding **pH, neutral conditions** are preferred, though they can tolerate a range between 5 and 9.
- As photophobic organisms, earthworms should be kept in **environments shielded from light**, and vermicomposting systems should be designed accordingly.

Earthworms have not been identified as hosts or vectors of parasites harmful to humans.

Important !

Vermicomposting efficiency is maximized when the biological needs of the worms are fully met; otherwise, the process may become significantly slower!

An earthworm growing under optimal conditions can process a quantity of waste equivalent to its own body weight per day. Therefore, the efficiency of a vermicomposting facility depends on meeting the nutritional requirements of the worms while maintaining ideal environmental conditions for their growth

Earthworm feeding

Earthworms adapt well to diets based on a wide range of organic materials. As they lack teeth, they can only ingest substances that are already in the process of decomposition. For this reason, it is advisable to subject the feedstock to a **pre-composting phase**.

The pre-composting phase is a composting process lasting approximately 15–20 days—which enhances palatability and improves conversion efficiency. Virtually all types of organic material can be processed by earthworms.

Once pre-composting is completed, an optimal earthworm diet should meet the following criteria:

- particle size below 2–3 cm,
- adequate porosity for drainage and aeration,
- a C/N ratio in the range of 20–30,
- and the absence of heavy metals, organic pollutants, or excessive protein content.

In general, worms prefer soft, moist organic residues

To determine the suitability of a particular diet for earthworm consumption, it is recommended to perform a **box test**. This involves feeding 50 worms with the material under evaluation.

After 24 hours, if fewer than 49 individuals remain alive, the diet is deemed unsuitable and should undergo further transformation before being offered to larger worm populations.

CAN THE QR CODE TO LEARN HOW TO MIX RESIDUES FOR THE PRE-COMPOSTING PHASE.

CHECK PAGES 16 AND 17: CONSTRUCTION OF A WINDROW/COMPOST PILE.

Practical knowledge

Under optimal conditions, an earthworm can process its own body weight in organic matter per day, of which approximately 60% is excreted as vermicompost. It is estimated that an adult worm produces on average 0.3 grams of vermicompost per day.

4. Vermicomposting facilities and their implementation

Vermicomposting can be carried out in a **wide variety** of facilities, ranging **from domestic vermicomposters** and stacked bin systems at small to medium scales, **to large-scale production beds** of variable size.

Ideally, these facilities should be located:

- in shaded areas (natural or artificial),
- near a water source,
- on slightly sloped terrain to facilitate leachate drainage,
- and as close as possible to the source of organic waste.

Domestic vermicomposters may be built from a range of materials and can vary in shape and complexity—from a single container to a stack of multiple trays. In these systems, earthworms are particularly vulnerable to suboptimal conditions, so any errors related to feeding, moisture levels, shading, or ambient temperature can quickly lead to the collapse of the worm population. Typically, the bottom tray collects excess liquid, while the remaining trays are used for vermicompost production. Image 1 presents several simple vermicomposter models.

Image 1: Household Models for Small-Scale Vermicomposting Systems

Photos: Authors' own

Practical knowledge

How to start a vermicomposting facility

The start-up of a vermicomposting facility must be based on the introduction of a healthy, and generally composed by adults, earthworm population. An optimal commercial slab population is typically composed of 60% juvenile worms, 40% adult worms, and approximately 500 cocoons per square meter.

A facility can initially be populated with around **5,000 worms/m²**. Under optimal growth conditions, this population can expand to approximately **20,000 worms/m²** within three months. At that point, the population may be divided to extend the working surface by a factor of about four, allowing for gradual expansion of the facility until the total designated surface area is fully occupied. Alternatively, the process can be accelerated by investing in a larger initial population of worms.

- Once the target production area has been reached, any surplus worms may be sold to other vermicomposting operations or diverted for use in other vermiculture-related products.

To properly manage and diagnose the condition of a vermiculture system, it is advisable to conduct **periodic worm counts**, as these serve as reliable indicators of potential issues related to feeding practices or humidity levels.

Practical knowledge

Designing key operational zones in vermiculture installations

Vermicomposting facilities should be designed with the following functional areas:

1. **Breeding Area.**
   A small section (at least 10% of the production area) dedicated to maintaining ideal living conditions and closely monitoring worm populations. This zone serves as a reserve to replenish production beds or to recover from disturbances.

2. **Production Area.**
   This area consists of beds or other containment structures in which earthworms process organic waste into vermicompost. Beds should be emptied after the completion of the production cycle. Before harvesting the vermicompost, worms must be separated from the final product, typically using trap screens and/or auxiliary boxes placed on top of the bed and filled with fresh organic matter to attract the worms. Maintenance and feeding operations in this area can be mechanized, enabling the development of large-scale systems.

3. **Maturation and Conditioning Area.**
   Once the worms have been removed, the vermicompost must undergo a maturation period of 25–30 days, during which the organic molecules stabilize and polymerize, thereby enhancing the quality of the final product. Moisture content should be reduced to a maximum of 40%.

Photo: Earthworms on hand for organic fertilizer farming by Kckate16 for Envato

4. **Packaging and Labeling Area.**
   If the vermicompost is intended for commercial distribution, the facility should be equipped with machinery to support the packaging process. Sieving may also be necessary to homogenize the product.

5. **Auxiliary Zones.**
   These areas are designated for storing tools and equipment such as thermometers, sampling cubicles, worm counting stations, moisture meters, manual turners, auxiliary boxes, and worm trapping meshes.

6. **Diet Conditioning Area**.
   It may be necessary to store various organic residues and allocate space for pre-composting operations.

The facility layout should facilitate the execution of the four fundamental tasks in vermicompost production: bed setup, feeding, irrigation, and harvesting.

a)

b)

c)

Image 2: Key Operational Zones in Vermiculture Installations.
a) Breeding area, b) Pre-composting area, c) Auxiliary Areas

Photos: Authors' own

5. Vermicomposting products and their uses

Vermicompost

The composition of the final vermicompost is largely dependent on the earthworm diet, making it difficult to establish standard nutrient content values. However, average values are provided in Table 1 for reference.

Table 1. Nutrient Composition of Vermicompost Derived from Different Feedstock Sources

Vermicompost from	N (%)	P_2O_5 (%)	K_2O (%)	Other characteristics
Cattle manure[1]	1.6-2.7	0.2-0.9	0.2-0.5	Neutral pH
Pig manure[1]	2.1-3	0.9-2.7	0.08	Slightly acidic pH
Coffee residues[1]	3.4-3.7	0.02-0.3	0.1-0.2	Low electrical conductivity
Leaf litter[1]	1.8-2.4	0.6-1	0.2-0.3	Easily decomposable material
Pruning residues[2]	2.2-2.5	0.1-0.2	1.8-2.5	Very low electrical conductivity
Cattle manure[2]	1.8-2.2	0.05-0.1	2.1-2.6	Slightly alkaline pH
Green waste[2]	2.1-2.5	0.6-1	2.8-3.2	High electrical conductivity
Cereal straw[2]	1-1.5	0.01-0.3	1.3-1.7	High electrical conductivity

Source: [1] Martinez et al., 2010. Lombricultura. Manual práctico. [2] Own data.

The value of vermicompost lies not only in its mineral composition, but also in the fact that it passes through the earthworm's digestive tract. This process enriches it with beneficial internal **microorganisms** that aid in decomposition, as well as with organic molecules such as **vitamins**, **hormones**, and **enzymes**. These features enhance the versatility of its application, positioning vermicompost as one of the **highest-quality and most valuable organic fertilizers** available in the market.w

The high microbial content promotes rapid mineralization upon application, improving the bioavailability of nutrients for plant uptake. Furthermore, this property makes vermicompost an effective tool for restoring **degraded soils**, including those affected by erosion or forest fires.

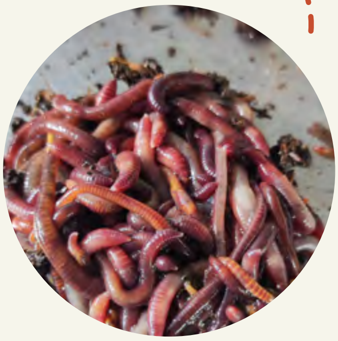
Photo: Pre-composting pile. Authors' own.

Other products derived from vermiculture

Vermicomposting facilities and worm breeding systems can yield additional products beyond vermicompost:

Earthworms

Once the facility reaches its desired scale, surplus worms can be harvested. These may be used as **animal feed** (especially for poultry), **fishing bait**, or sold to establish new vermiculture operations. This can be a profitable commercial activity, provided that appropriate conditions for transport are met.



a)

Worm flour

A fine powder obtained by drying and grinding earthworms. It is used in the **pharmaceutical industry, pet food**, and **livestock feed**, and is currently being studied for its potential in **human protein consumption**.

b)

Vermicompost tea

A liquid solution prepared at a ratio of 1:10 (**vermicompost:water**) from the solid product. Stabilization of the organic matter is achieved through **forced aeration** for 24–72 hours using simple equipment such as pumps and containers.

c)

d)

Liquid fertilizer

This may originate from excess water applied to vermicompost production beds. Like vermicompost tea, it must undergo a stabilization process for its organic matter content, typically involving **aeration mechanisms** similar to those used for preparing compost tea.

Source:
a) Authors' own
b) AI-generated image by Freepik
c) Authors' own
d) Bio-fermented water by thanyapatm

Uses of vermicompost

Although the primary application of vermicompost is as a solid soil fertilizer, several other uses have been documented, including as:

- a **substrate for seed germination** and **ornamental plants,**
- a **restorative agent** for soils degraded **by erosion or fire**,
- and a **remediation agent** for **contaminated soils**.

Numerous studies have also identified its potential in **soil biodisinfection**, due to its natural suppressive effects.

The recommended application rate of vermicompost varies widely, depending on its composition. A typical average is around **2 tons per hectare**, although rates up to **8 tons** per hectare may be advised for highly demanding horticultural crops. The degree to which it should be combined with mineral fertilizers depends on the type of soil and specific crop requirements. In general, vermicompost acts as a valuable complement to mineral fertilization, potentially **reducing synthetic fertilizer use by 25–50%**. In some cases—particularly in organic farming systems—it may even serve as the sole source of fertilization.

Field and laboratory studies have shown **residual effects** of vermicompost on subsequent crops beyond the one initially fertilized, further reinforcing its agronomic value.

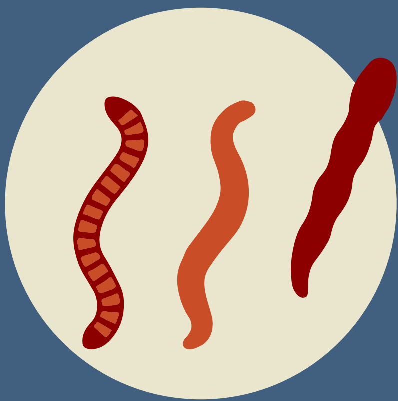
To keep in mind

The viability of using vermicompost as a fertilizer depends greatly on **self-sufficiency** in its production. As a relatively expensive product in the commercial market, farms that produce their own vermicompost can achieve full substitution. However, if its use relies solely on market purchases, the quantity applied is likely to be significantly reduced.

For this reason, it is essential to promote and manage **small- and medium-scale vermicomposting** systems that allow smallholders to meet their organic fertilization needs autonomously.

6. Key principles of vermicomposting

Vermicomposting is the process of transforming organic waste through the joint action of earthworms and microorganisms.



Eisenia fetida and *Eisenia andrei* are the most widely employed species, while *Eudrilus eugeniae* is best adapted to subtropical climates.

Virtually all organic residues can be vermicomposted, provided that **biological needs of worms are met** (i.e. organic beds with 80% moisture content, temperature 15-25ºC, neutral pH and darkness)

Vermicomposting facilities can yield additional products: earthworms, worm flour, vermicompost tea, and liquid fertilizer.

The resulting vermicompost is one of the **highest-quality and most valuable organic** fertilizers available in the market. A typical average dose is around **2 tons per hectare**.

Vermi composting can be carried out in a **wide variety of facilities**, ranging from domestic vermicomposters to large-scale production beds of variable size.

A pre-composting phase of the residues to make them tasty for earthworms is usually needed.

Your notes ...

7. Additional information

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