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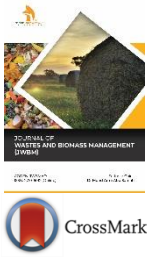

RESEARCH ARTICLE

VERMICOMPOST: A PARADIGMATIC REVIEW OF ITS AGRONOMIC AND ECOLOGICAL SIGNIFICANCE

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ABSTRACT

Vermicompost is a nutrient-rich, peat-like biofertilizer characterized by its low carbon-to-nitrogen ratio, high porosity, excellent aeration, drainage, and water retention properties, promoting microbial activity. It contains 0.4–0.66% nitrogen, 1.16–1.93% phosphorus, 0.26–0.42% potassium, essential trace elements, and beneficial soil microorganisms. In contrast to agrochemicals, which degrade soil fertility and harm ecosystems, vermicompost is a sustainable alternative that enhances plant growth by 4–5 times and improves productivity by 30–40%. Produced by epigeic earthworms like *Eisenia fetida* and *Eisenia andrei*, vermicompost benefits from their efficient waste processing, rapid organic matter decomposition (45–50 days) and adaptability to diverse environments. Production systems include batch and continuous flow methods. Vermiwash or vermicompost tea, is an added byproduct offering liquid nutrients for plants. This review discusses the production methods of vermicompost and vermiwash or vermicompost tea and their importance as well as the significance of vermicompost for sustainable production.

KEYWORDS

Earthworm, Nutrient, Sustainable, Vermicompost, Vermiwash

1. INTRODUCTION

The Green Revolution in the 1960s boosted food production through the extensive use of chemical fertilizers. Today, these fertilizers meet the food needs of 50% of the global population (Erisman et al., 2008). The use of chemical fertilizers leads to the problem of environmental pollution and affects soil health and plant productivity due to the disturbance interaction among plants, soil, and microorganisms (Harman et al., 2020). The harmful effects of chemical fertilizers have shifted scientists' focus toward "green substitutes" with lower environmental impact (Benedetti et al., 2015). Vermicompost is a promising alternative to traditional chemical fertilizers. Vermicompost is a finely textured, peat-like material characterized by a low carbon-to-nitrogen ratio, high porosity, and excellent aeration, drainage, and water retention. It also has increased microbial activity. This valuable substance is produced through the non-thermophilic biodegradation of organic materials, aided by earthworms and the microbes that work alongside them (Edwards and Burrows, 1988; Atiyeh et al., 2000a, 2000b; Arancon et al., 2004). Vermicompost produced by earthworms, is considered one of the best organic fertilizers, containing worm castings, organic materials, humus, and microorganisms. According to Shubha (2021), vermicompost is cost- effective method which can efficiently reuse food waste, agro-industrial waste recycles and animal waste etc. which enhance soil nutrient status and increases production of fruits and vegetables. Vermicompost is eco-friendly which helps to reduce use of chemical fertilizers which results promoting 4-5 times or (30-40) % growth of plants as compared to chemical fertilizers (Mukherjee et al., 2016).

2. KEY EARTHWORM SPECIES FOR OPTIMAL VERMICULTURE PERFORMANCE

Several earthworm species, including *Eisenia fetida*, *Dendrobaena veneta*, *Drawida nepalensis, Lumbricus rubellus, Eudrilus eugeniae, Polypheretima elongata* and *Perionyx excavatus* are known for their potential in vermicomposting. Due to rapid reproduction, high conversion of organic waste as well as adoption on different environment *Eisenia fetida* and *Eisenia Andrei* are commonly used in south-east Asia (Dominguez, 2004; Gunadi, 2011). Ferber (2019) classified earthworms into two groups: **Epianecic** - surface-dwelling species and **Epigeic** - burrowing species.

Table 1: Comparing between Burrowing and non-burrowing (Nagavallemma et al., 2004).

Burrowing	Non-burrowing
➢ ***Peritima elongata*** and ***Peritima asiatica*** are burrowing-type earthworms.	➢ ***Eisenia feitda*** and ***Eudrilus eugenae*** are non-burrowing -type earthworms.
➢ Live deep in the soil.	➢ Live in the upper layer of soil surface.
➢ Life span for 15years.	➢ Life span for 28 months.
➢ Pale in colour.	➢ Red or Purple colour.
➢ 20 to 30 cm long.	➢ 10 to 15 cm long.
➢ Convert organic waste into vermicompost slower than the non- burrowing earthworms.	➢ Convert organic waste into vermicompost faster than the burrowing earthworms.

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3. Nutritive Value of Vermicomposting

1. **Nutrient Conversion**: During vermicompost production, microorganisms present in compost convert into plant-available forms (Kaushik and Garg, 2003).
2. **Macronutrients in vermicompost:**

   Micronutrients are highly present in vermicompost:

   a. Nitrogen: 0.4% to 0.66%

   b. Phosphorus: 1.16% to 1.93%

   c. Potassium: 0.26% to 0.42% (Srivastava et al., 2002).
3. **Micronutrients and Beneficial Microbes**: 10^2 to 10^6 per gram microbes such as Actinomycetes, Azotobacter, Rhizobium, Nitrobacter and Phosphate Solubilizing Bacteria (PSB) are present in vermicompost which promotes plant growth (Edwards et al., 2004; Sinha et al., 2010).
4. **Carbon to Nitrogen Ratio**: Vermicompost increase nutrients such as N, P, K and reduces carbon-nitrogen ratio.
5. **Plant Growth Regulators**: Auxins, cytokinins, and gibberellins are highly present in vermicompost which are plant growth regulators (Edwards et al., 2004; Sinha et al., 2010).
6. **Quality of Vermicompost**: According to the study, quality of vermicompost depend upon feeding materials and species of earthworm (Suthar, 2007). *Perionyx excavatus* can decompose waste materials effectively and reduce Carbon and increase N, P, K.
7. **Humic Acid Benefits**: Worm casts is rich in humic acid which binds nutrients such as phosphorus, potassium, sulfur, iron and calcium which release according to the needs of the plants and helps in plant growth (Canellas et al., 2002; Zandonadi et al., 2007; Adhikary, 2012).
8. **Worm Casts**: According to Das (2019), worm casts are excreta of worms which are called black gold because it highly enhances soil health and nutrients in soil.

4. Methods of Vermicomposting

Pilli (2019) reported that vermicomposting can be accomplished using two distinct systems, namely batch processing and continuous flow systems.

Batch systems:

In this method, fixed amount of vermicompost is prepared. Limited quantity of feed is provided to worms which then break on specific period of time. After certain period composted is collected and clean the system for next cycle of compost preparation. This method is suitable for small scale farmers because of easy handling and less need of equipment's.

Continuous flow systems:

In this method, feed is regularly provided to the worms and collection of worms continuously. This method is suitable for large scale farmer because it requires advance design technique for the separation of worms and compost. In continuous flow systems, feedstock is added regularly to the vermicomposting setup, and vermicompost is collected continuously. These systems need biggest amount of feed and more advanced design, including tools to separate the compost and worms and to manage the system's moisture levels.

5. Vermicompost Production Process

Recent studies indicate that the effectiveness of vermicompost depends on a defined multi-stage preparation process that ensures controlled waste decomposition and consistent nutrient quality (Saha, 2022).

1. **Select the location:**

   Choose a shaded area with minimal water accumulation.
2. **Set up the pit or box:**
   - For a pit, use dimensions of 3.5 m x 1.2 m x 0.6 m.
   - For a wooden box, use dimensions of 50 cm x 50 cm x 60 cm.
   - Maintain 0.5 meters of space between pits or boxes.
3. **Prepare the layers:**
   - Start with an 8-10 cm thick layer of slow-decomposing materials like maize, sorghum, or millet stalks.
   - Add a 7-8 cm layer of fully decomposed cow dung on top.
   - Alternate these two layers 4 to 5 times.
1. **Add earthworms:**

   Add around 1000 to 1500 (1Kg) earthworms to a pit of 3.5 m x 1.2 m x 0.6 m.
2. **Cover and maintain:**

Cover the pit with a thin layer of jute fabric. Water it lightly every 2-3 days, avoiding excess water.

3. **Aerate the bed:**

   Turn the bed once every 30 days to ensure proper aeration.
4. **Time and conditions:**
   - Maintain a temperature of 20°C to 30°C.
   - Keep the moisture level in the bed at 40-50%.
   - Vermicompost is ready in 50-60 days.

6. How to Extract Vermicompost?

Maintaining optimal moisture levels is critical until the substrate achieves complete humification, characterized by a distinct granular texture and melanized appearance (Saha, 2022). Instead of creating a new worm bed, worm harvesting is often practiced to sell the worms. Vermicomposting uses worms to break down organic matter into nutrient-rich fertilizers known as vermicompost or worm castings. Once the compost is fully decomposed, the worms can be collected. These worms can be sold for bait on fishing and feed for animals.

Procedure for extraction of vermicompost:

1. **Prepare new bedding**: Newspaper, coconut coir are used for bedding material, which moisten it with water left for 1-2 days before adding worms.
2. **Shift compost**: Shifting the compost to another site of bin for creation of space to transfer the worms.
3. **Add fresh food**: Adding kitchen wastes on new bedding for attraction of worms
4. **Allow migration**: In search of food worms migrate to new bedding after few days to a week which is depend upon population of worms and availability of food.
5. **Harvest the worms**: Hand or worm harvester is used to collect remaining worms after migration of worms to new bedding.
6. **Prepare for sale**: Collected worms are packed in containers with some bedding materials and fresh food. During transport moist and cool environment should be provided to stay alive of worms.

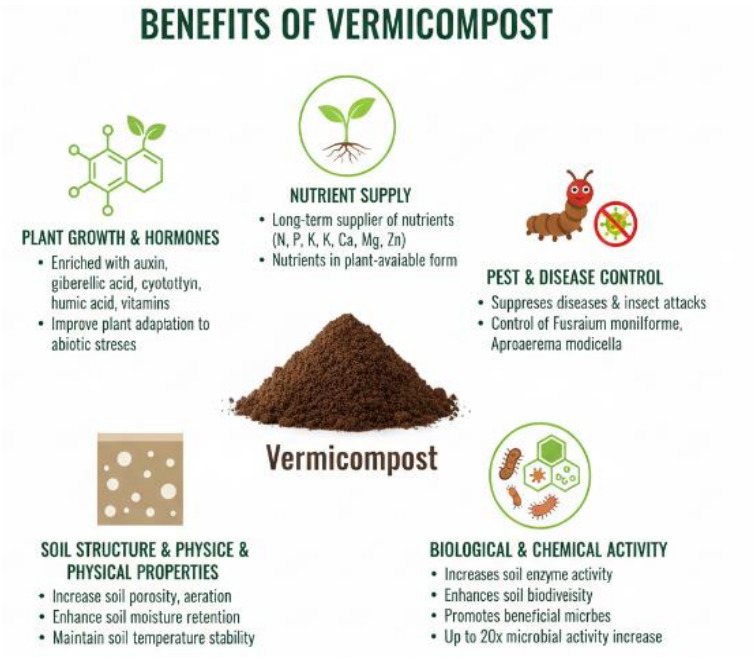

Figure 1: Benefits of vermicompost (Rehman et al., 2023).

7. Vermiwash and Its Production

A liquid extracted from vermicompost after feeding of the organic materials like leaf litter or cow dung by earthworms is vermiwash (Tharmaraj et al., 2011). While vermicomposting methodologies vary between batch and continuous processing, both frameworks are unified by the requirement for consistent raw material supply and scheduled worm density management (Munroe, 2007). As utilized indigenous (*Lampito mauritii*) and exotic (*Eisenia fetida, Eudrilus eugeniae)* earthworms to create vermicompost/vermiwash in 2x2x2m pits layered with pebbles, sandy soil, organic compost, and a cow dung-leaf litter mix (1:2 ratio), covered to retain moisture (Tharmaraj et al., 2011). As used shaded 1x1x0.75m brick tanks containing 500 kg of composted coffee pulp and cow dung (Raphael and Velmourougane, 2011). Earthworms (*Eudrilus eugeniae*, *Perionyx ceylanensis*) were inoculated (1 kg per tank), with regular watering and gunny bag covers to maintain moisture and facilitate composting.

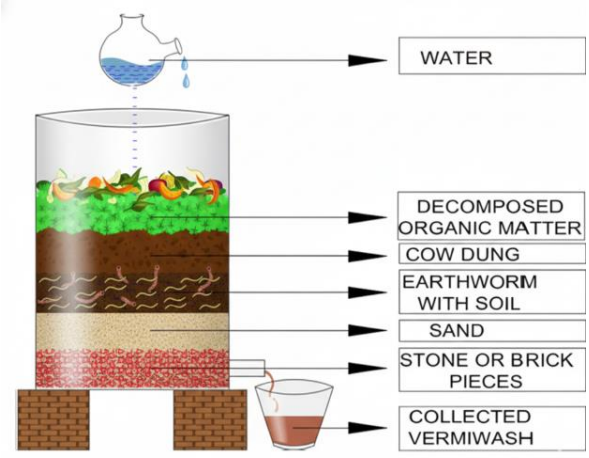

Figure 2: Vermiwash Production (Gudeta et al., 2021).

Table 2: Components and role of Vermiwash.

Components of Vermiwash	Role of Vermiwash	References
Micronutrients (N, P, K)	Growth and Development in plants	Manyuchi et al., 2013
Micronutrients (Fe, Cu, Zn, Mn)	Growth promoter	Varghese and Prabha, 2014
Decomposer Bacteria	Suppress pathogen	Mondal et al., 2015
Carbohydrates	Provide energy	Varghese and Prabha, 2014
Proteins	Provide immunity	Varghese and Prabha, 2014
Auxin	Enhance root tip length	Rajasooriya and Karunarathna, 2020
Cytokinin and Gibberellin	Rapid cell division	Rajasooriya and Karunarathna, 2020

Table 2 (cont): Components and role of Vermiwash.		
Vitamins	Facilitates growth and development of plant	Das et al., 2014; Tripathi et al., 2005
Protease and Phosphatase	Development and growth	Verma et al., 2018
Azotobacter sp and Rhizobium sp	Improves seed germination and helps in the fixation of Nitrogen	Nandhini and Venmanthi, 2017
Ca, Mg and Na	Increases the disease resistance, Ca promotes microbial activity	Verma et al., 2018; Manyuchi et., 2013
Amino acids	Chlorophyll Synthesis	Das et al., 2014
Amylase, cellulase	Stabilize physical, chemical and biological properties of soil as well applied in carbon turnover by degrading organic matter.	Das et al., 2014; Tripathi et al., 2005

8. Significance of Vermicompost for Sustainable Agriculture

Vermicompost is an excellent source of plant nutrients, containing 0.4–0.66% nitrogen (N), 1.16–1.93% phosphorus (P), and 0.26–0.42% potassium (K), along with essential micronutrients and beneficial soil microbes. It is enriched with plant growth hormones including auxins and gibberellins, vitamins and enzymes that significantly enhance both crop and soil productivity. As an eco-friendly fertilizer, vermicompost improves agricultural output by supplying the soil with vital nutrients and beneficial microorganisms that naturally promote plant growth (Gudeta, 2021). Similarly, vermicompost improves physiochemical and biological characteristics of soil through neutralizes soil pH, reduces nutrient losses, lowers soil compaction, increases the soil's infiltration rate and enhancing phosphorus availability and plays role on conversion of organic matter into nitrogen form (ammonia). Vermicompost is free from pathogens, toxic chemical elements as well as weed seeds which reduce the occurrence of harmful pests and microorganisms.

9. Latest Research Conducted on Nepal

Acharya (2024) reported that the application of vermicompost increased okra fruit yield by 120.5% compared with control (non-fertilized treatment). Research by Ghimire et al. (2023) indicates that a 50/50 ratio of synthetic nitrogen (urea) to organic matter (vermicompost) optimizes the nutrient profile necessary for superior bitter gourd yields. Bajal (2019) reported that among substrates used for vermicomposting, Lantana camara had the highest nitrogen content (2.53%), followed by banana pseudostem (2.49%). While Lantana's phosphorus (1.38%) was slightly lower, it was comparable to mycostraw (1.46%) and vegetable waste (1.43%). In terms of potassium, Ageratum was highest (3.29%), followed by banana pseudostem (2.46%) and Lantana (2.28%). Overall, Lantana, Ageratum, and banana pseudostem were richest in NPK, but all substrates showed strong manuring potential and can be effectively utilized through vermicomposting. Research conducted on *Eisenia fetida*; the multiplication and reproduction were achieved highest in the mixture of cow dung and sawdust vermicompost and lowest in the mixture of cow dung and banana pseudo-stem vermicompost. But the amount of vermicompost was found to be highest in cow dung as sole source of feeding material as compared to the cow dung mixed with plant materials (Chaulagain et al., 2017).

10. Conclusion

Vermicomposting epitomizes an environmentally conscientious and sustainable paradigm for waste remediation, converting organic refuse into nutrient-dense humus through the biochemical prowess of earthworms. Vermicompost is eco-friendly, enhances soil biodiversity by promoting beneficial microbes. Vermicompost maintain soil temperature and increase soil porosity and moisture retention capacity of soil. Vermicompost is enriched with auxin, gibberellic acid and vitamins as well as have capacity to suppress the diseases and insect's attack. Thus, the use of vermicompost should be increase for sustainable agricultural production.

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