Research Paper E-ISSN NO : 2455-295X | VOLUME : 10 | ISSUE : 5 | MAY 2024

VERMICOMPOSTING: A COST-EFFECTIVE AND ECO-FRIENDLY APPROACH TO SOLID ORGANIC WASTE MANAGEMENT

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ABSTRACT:

Vermicomposting presents a cost-effective and environmentally friendly approach to solid organic waste management, addressing the growing global concern of waste accumulation and its environmental impact. This process utilizes earthworms to decompose organic materials into nutrient-rich vermicast, diverting waste from landfills and reducing greenhouse gas emissions. Vermicomposting is economically viable and adaptable to various waste management strategies. This review explores the benefits of vermicomposting, including its potential to create closed-loop systems within a circular economy framework, contributing to sustainable agricultural practices and promoting environmental protection. While practical implementation requires careful consideration of environmental conditions, feedstock selection, and system design, vermicomposting presents a promising approach for policymakers, urban planners, and waste management practitioners seeking effective and environmentally sound waste management solutions, particularly in developing economies.

The review also acknowledges the challenges and limitations associated with vermicomposting, such as the sensitivity to environmental factors and the potential for contamination. Finally, it emphasizes the importance of careful management practices, appropriate feedstock selection, and pre-treatment methods to maximize the efficiency and effectiveness of vermicomposting. This approach offers a sustainable and economically viable solution for municipalities, agricultural operations, and communities seeking to minimize waste and promote a circular economy.

KEYWORDS:

VERMICOMPOSTING, ORGANIC WASTE, EARTHWORMS, EISENIA FETIDA, VERMICAST, SUSTAINABLE AGRICULTURE, WASTE REDUCTION, ENVIRONMENTAL PROTECTION.

PAPER ACCEPTED DATE:	PAPER PUBLISHED DATE:
26th May 2024	31st May 2024
IMPACT FACTOR VALUE:	**PAPER DOI LINK:**
5.983 (SJIF)	https://zenodo.org/records/14531290

1. INTRODUCTION

The Management of solid organic waste is a serious worldwide problem because accumulation of such materials may cause great environmental and public health problems. Organic wastes, which could account for as much as 60% of municipal solid wastes, include food waste, garden refuse, paper, and cardboard. These products can lead to the emission of greenhouse gases, pollution of soil and water, and even exhaustion of natural resources through improper disposal. Vermicomposting is the application of earthworms for decomposing organic waste into a nutrient-rich soil amendment. In the management of solid organic wastes, vermicomposting has emerged as an attractive solution to this problem. Through the process of vermicomposting, there are numerous benefits that make the solution extremely attractive for handling solid organic waste. Vermicomposting represents an economically viable and environmentally sustainable method for waste management that offers various benefits.

This not only prevents organic waste from reaching landfills but also generates a productive soil amendment that promotes fertility and plant growth (Behera, 2019). In addition, vermicomposting is an easy process that can be included in any waste management strategy. This is a current research article in pursuit of presenting an expansive review of vermicomposting ability as a plausible method to manage solid organic waste with the prospect of sustainability efficiently.

2. LITERATURE REVIEW

The problem of solid organic waste is considered an environmental problem with serious dimensions since improper elimination of such wastes can degrade natural resources, pose direct health threats to human society, and also affect ecological balance (Khalid *et al.*, 2011). A

possible corrective measure can be vermicomposting-an environmentally sustainable method which involves earthworms for biodegradable waste transformation to a nutrient-rich fertilizer. As stated by Kaur (2020), vermicomposting is an economically feasible biotechnological process that involves earthworms and microorganisms in the conversion of organic waste into a sanitized, detoxified, and nutrient-rich final product, as stated by Yatoo *et al.,* (2020) and Kaur (2020). This process can efficiently manage different types of organic wastes, including agricultural by-products, municipal solid waste, and industrial refuse, such as paper mill sludge and spent brewing yeast. (Yatoo *et al.*, 2020; Khalid *et al.,* 2011; Kaur, 2020).

Vermicomposting offers numerous merits that make it an impressive technique to handle solid organic waste. This technology ensures the complete decomposition of very diverse materials, many being difficult or impossible to process through any other type of decomposition process. The generated vermicompost consists of vast amounts of humus along with other essentials like plant nutrients and positive microorganisms in it, thereby making excellent, organic fertilizers that boost and promote further growth of healthy plants in soil. According to Kaur (2020), the adaptability inherent in vermicomposting is a significant advantage, allowing the process to be modified to address the unique requirements and limitations present in various waste management environments, from extensive centralized operations to smaller, community-oriented initiatives.

3. THE BENEFITS OF VERMICOMPOSTING

One of the main benefits of vermicomposting is its cost-effectiveness. The method of vermicomposting is rather simple and, therefore, easy to implement both at the household and community level, with minimum investment in infrastructures and equipment (Arelli *et al.,* 2020) (Kouhihabibi & Mohammadi, 2023). Another benefit is the fact that vermicompost, a product resulting from vermicomposting, can be sold or applied as a fertilizer, providing additional income or saving money on expensive commercial fertilizers.

Vermicomposting is also an incredibly environmentally friendly way of managing wastes. Unlike other composting that often results in the emissions of greenhouse gases like methane and carbon dioxide, vermicomposting is a largely aerobic process that reduces the emission of harmful gases (Nordahl *et al.,* 2023). Moreover, vermicomposting can significantly reduce the amount of organic waste volume which could divert from landfills reducing environmental impacts of waste management. (Behera, 2019)

There are many advantages the vermicompost can provide as an amendment to the soil environment. This is because it has a large amount of organic matter, nutrients, and beneficial microorganisms, improving the structure and water-holding capacity of soil and, as a whole, the overall health of the soil, which is said to have good effects on plant growth, reduced dependence on synthetic fertilizers, and thus more sustainable agricultural practices (Behera, 2019).

4. THE PROCESS OF VERMICOMPOSTING

Vermicomposting is a process that involves using specific earthworms like *Eisenia fetida* or *Eisenia anderi*, commonly known as the red wiggler (Fig. 1.A, B,), *Eudrilus eugeniae*, which is referred to as African night crawlers, to break down organic waste into nutrient-rich compost. There are several ways of making vermicompost based on the type of substrate used and the methods of bedding followed.

The process starts with the addition of organic waste, including food waste, garden waste, cow dung, crop residues, bio-wastes, paper, and other biodegradable wastes into a designated vermicomposting unit. The earthworms then consume the organic matter, breaking it down through their digestive system and producing a nutrient-rich material known as vermicompost. The necessary ingredients of vermicomposting include an ideal proportion of carbon and nitrogen, adequate amounts of oxygen, and optimal levels of moisture. Vermicomposting can indeed minimize organic waste that would have otherwise entered landfills to generate more methane, a super greenhouse gas, and also to generate leachate contaminating soils and water resources.

FIG.1. (A., B.) RED VORMIWORM CULTURE AND C. SUBSTRATE FOR VERMICOMPOSTING

5. CHALLENGES AND LIMITATIONS

While vermicomposting has many benefits, it is not without its challenges and limitations. For example, the process can be sensitive to environmental factors, such as temperature and moisture levels, which must be carefully monitored and maintained to ensure optimal decomposition (Nordahl *et al.,* 2023). Moreover, the entry of contaminants, such as heavy metals or toxic chemicals, can be harmful to the health of earthworms and the quality of the final vermicompost product.

According to the review of literature, choice of feedstock and the pre-treatment of organic waste could also affect the efficiency and effectiveness of the vermicomposting process. In addition, the scale of vermicomposting operations can also be a limiting factor because larger-scale systems require more specialized equipment, skilled labor, and complex management practices to ensure optimal performance and consistency in the quality of the final product (Mu *et al.,* 2017) (Behera, 2019) (Kuhlman, 1990) (Sadeghi & Sayaf, 2015).

6. METHODOLOGY

This research paper bases its study on a critical examination of the literature that surrounds the current

situation with regard to vermicomposting as a viable option in managing solid organic waste. Studies and reports from academia, documents from researches, and also industry reports have been sourced from the technical, environmental, and economic dimensions of vermicomposting.

The principal references used in this study include (Behera, 2019), which focuses on the benefits of composting that redirects waste from landfills through a high-quality soil amendment. Thirdly, there is; Weidner *et al.,* 2018, highlight possibilities with vermicomposting and anaerobic digestion within the context of the city and resource circularity in urban agriculture. Fifth, there is Khalid et al., 2011, provided a holistic explanation for the anaerobic digestion concerning organic waste and the effects that affect its digestion efficiency. Lastly, there's; Weidner *et al.,* 2018 where this research explains the importance that needs to be put into vermihumus compostation, especially for organic waste urban agriculture purposes.

Composting is considered a sustainable method of solid organic waste management. The study highlighted the various benefits of vermicomposting, including its cost-effectiveness (Khalid *et al.,* 2011; Sadeghi & Sayaf, 2015), environmental sustainability (Behera, 2019), and the potential applications of vermicompost as an amendment for soil quality (Girish *et al.,* 2020).

The review of relevant literature has involved a systematic search for scholarly databases, such as Science Direct, Springer, and Google Scholar, utilizing the following search terms: "vermicomposting," "organic waste management," and "soil amendment." This inquiry generated quite relevant studies and reports, which became subjects of critical analysis to develop themes, findings, and limitations over the use of vermicomposting in solid organic waste management.

7. RESULTS

The results were then compiled from these sources to develop a more profound understanding of the process of vermicomposting, its benefits, and the challenges associated with its implementation. The literature review shows some of the main findings of vermicomposting as a sustainable alternative of solid organic waste management

1. **Cost-effectiveness**: Vermicomposting is a low-cost process that can easily be implemented at the household or community level with minimum investment in infrastructure and equipment (Behera, 2019).
2. **Environmental sustainability:** Vermicomposting mainly happens in aerobic conditions, which heavily reduces the release of greenhouse gases, specifically methane and carbon dioxide in comparison to regular composting methods (Behera, 2019) (Nordahl *et al.,* 2023).
3. **Soil amendment:** Vermicompost is a nutrient-rich soil amendment that can improve soil structure, water-holding capacity, and overall soil health, thereby promoting more sustainable agricultural practices (Behera, 2019).
4. **Reducing waste:** Vermicomposting will significantly reduce the amount of organic waste that would have been landfilled, thereby saving the generation of methane and leachate.

However, the process could be affected by environmental factors such as temperature and humidity, and even the existence of pathogens would deteriorate both earthworms' health and the quality of vermicompost obtained. (Khalid *et al.,* 2011) (Weidner *et al.,* 2018) (Sadeghi & Sayaf, 2015) (Behera, 2019)

Vermicomposting is considered eco-friendly for several reasons:

- **Waste Reduction:** Vermicomposting significantly reduces organic waste going to landfills. Earthworms consume organic materials, reducing waste volume by 40-60% (Nagavallemma *et al.,* 2004). This lessens the burden on landfills and minimizes the production of harmful greenhouse gases like methane, which are released during the decomposition of organic matter in landfills.
- **Nutrient-Rich Fertilizer:** The end product, vermicast, is a nutrient-rich organic fertilizer (Kaur, 2020) containing essential plant nutrients like nitrogen, phosphorus, potassium, and micronutrients. This reduces the need for synthetic fertilizers, which can have negative environmental impacts due to their production processes and potential for soil and water contamination.
- **Improved Soil Health:** Vermicompost enhances soil structure, aeration, and water retention (Nagavallemma *et al.,* 2006). It also introduces beneficial microbes that promote plant growth and disease resistance. These improvements contribute to healthier and more productive soils.
- **Reduced Reliance on Chemical Pesticides:** Vermicompost can suppress certain plant diseases and pests (Mu *et al.,* 2017), reducing the need for chemical pesticides, which can harm beneficial insects, pollute water bodies, and pose risks to human health.
- **Lower Energy Consumption:** Vermicomposting requires less energy input than other composting methods. The process relies on the natural activity of earthworms and microorganisms, minimizing the need for machinery or external heat sources.

8. DISCUSSION

The findings of this literature review show that vermicomposting has great potential as an economical and environmentally friendly means of solid organic waste management. This process can divert organic waste away from landfills, reduce greenhouse gas emissions, and

produce a valuable soil amendment that can enhance the sustainability of agricultural practices.

Vermicomposting is a decentralized method of waste management in the sense that it involves processing organic waste where it is produced and not relying on centralized systems for handling waste. This might especially be helpful in cities where most organic waste is generated. The transport of organic waste to distant disposal sites in cities often requires huge amounts of resources.

This also makes it possible to build closed-loop, circular economy structures in which waste is a critical input upon the use of vermicompost as a soil amendment.

9. CONCLUSION:

The literature review from the study reveals that vermicomposting is an eco-friendly, cost-effective method that would aid in the treatment of solid organic wastes. This particular process helps to minimize waste products directed towards landfills. These help to reduce gas emissions by a large percentage while preparing a nutrient-rich soil conditioner which, in turn, promotes sustainable farming systems. (Nordahl *et al*., 2023) (Sadeghi & Sayaf, 2015) (Khalid *et al.,* 2011) (Behera, 2019). However, the actual implementation of vermicomposting remains very sensitive to numerous factors: the preservation of ideal environmental conditions; the selection of appropriate feedstock; and the creation of an effective vermicomposting system. As the international community continues to grapple with the imperative issue of solid waste management, the views presented in this review may be useful in informing policymakers, urban planners, and waste management practitioners in developing and implementing effective, environmentally sustainable approaches to waste management.

The overall conclusions drawn by this research indicate that vermicomposting should be regarded as a feasible strategy for the sustainable administration of solid organic waste, especially in the milieu of developing and transitioning economies where there is an urgent requirement for economical and environmentally sound waste management alternatives.

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