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Review Article

Vermicomposting: A Sustainable Solution for Waste Management

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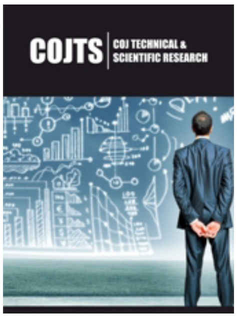

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Abstract

The excessive use of synthetic fertilizers and other agrochemicals during the Green Revolution has had negative impacts on soil health and the environment. In order to adopt a more sustainable approach to agriculture, it is necessary to use organic nutrient sources. Vermicomposting is a cost-effective and environmentally-friendly technique that uses worms to break down organic waste into nutrient-rich compost. Vermicomposting promotes soil biodiversity and improves plant health, leading to increased crop productivity and reduced yield loss. Vermicompost is a valuable tool for sustainable agriculture and safely treating agricultural, industrial, domestic, and medical waste.

Keywords: Microbes; Nutrient; Organic farming; Plant growth; Vermicompost; Waste management

Introduction

Soil is the foundation of life on earth, supporting a diverse array of organisms. However, industrialization and technological growth have led to sustainability challenges. Sustainability refers to the use of natural resources without compromising future generations' ability to meet their own needs. In the post green revolution era, vermicomposting has become increasingly important for sustainable agriculture and environmental conservation. The green revolution, which focused on increasing crop yields through the use of chemical fertilizers and pesticides, has caused soil degradation and environmental pollution. Due to this, the soil had lost its ability to produce due to a lack of organic matter amendments after being exposed to so many pesticides and chemical fertilizers. Vermicomposting can play a crucial role in promoting sustainable agriculture and protecting the environment. The region is known for its fragile ecosystem and delicate balance of natural resources, and vermicomposting can help to reduce the negative impacts of industrialization and technological growth. By providing a natural and sustainable alternative to chemical fertilizers, vermicomposting can improve soil health and fertility, support soil biodiversity, and reduce the reliance on harmful agrochemicals. Vermicomposting offers a sustainable alternative to chemical fertilizers, providing plants with the nutrients they need without harming the environment. By breaking down organic matter into nutrient-rich compost, it creates a natural and sustainable source of nutrients for plants. This can help reduce the need for chemical fertilizers and reduce the negative impacts of the green revolution on the environment [1]. Furthermore, vermicomposting can also improve the overall health and fertility of the soil. By creating a diverse ecosystem within the compost pile, vermicomposting can support a wide range of beneficial microorganisms and fungi, which can improve soil structure and promote plant growth [2]. The process of vermicomposting produces compost that is high in nutrients and beneficial microorganisms. This compost can be used to enrich the soil and promote plant growth, providing a natural and sustainable way to improve soil health and fertility. By creating a diverse ecosystem within the compost pile, vermicomposting can support a wide range of beneficial organisms and help create a healthy and sustainable environment for plants to thrive [3]. Furthermore, vermicomposting plays a crucial role in the post-green revolution era by providing a sustainable and natural alternative to chemical fertilizers and promoting soil health and fertility. It also supports soil biodiversity and reduces the reliance on chemical fertilizers, helping to create a more sustainable and environmentally-friendly agriculture system therefore; it is an effective way to foster a more sustainable and environmentally-friendly agriculture system.

Challenges of Waste Management

Organic farming and sustainable waste management practices are crucial for protecting the fragile ecosystem and preserving natural resources [4]. There are several challenges when it comes to waste management, including:

a) Generating a large amount of waste: As populations grow and consume more goods, the amount of waste being generated also increases. This can make it difficult for waste management systems to keep up.

b) Lack of proper infrastructure: In many parts of the world, there are not enough facilities and infrastructure in place to properly manage waste. This can lead to waste being improperly disposed of, causing environmental pollution and other problems.

c) Limited disposal options: In some areas, there may be limited options for disposing of waste, making it difficult to manage. For example, some areas may not have enough landfill space, or may not have access to recycling facilities.

d) High costs: Properly managing waste can be expensive, as it requires a significant investment in infrastructure and technology. This can be a challenge for governments and other organizations that are responsible for managing waste.

e) Resistance to change: In some cases, people may be resistant to changes in the way that waste is managed, such as implementing new recycling programs or reducing the use of plastic. This can make it difficult to implement effective waste management strategies.

f) Environmental impacts: Improper waste management can have serious environmental consequences, such as air and water pollution, and the contamination of soil. It can also contribute to climate change by releasing greenhouse gases into the atmosphere.

Organic waste, which includes food or agro waste, can be challenging to manage for several reasons [2]. Some of the specific challenges of organic waste management include:

a) High volume: Organic waste makes up a significant portion of the waste generated by households and businesses. This can create logistical challenges for waste management systems, as there is often a large amount of organic waste to collect and process.

b) Lack of infrastructure: Many areas do not have the necessary infrastructure, such as composting facilities, to properly manage organic waste. This can lead to organic waste being disposed of in landfills, where it can create environmental problems.

c) Odor and pest problems: Organic waste can produce unpleasant odors and attract pests, such as flies and rodents. This can be a problem for residential areas, as well as for facilities that are processing organic waste.

d) High costs: Collecting, transporting, and processing organic waste can be expensive, particularly if it needs to be transported over long distances to facilities that can handle it.

e) Limited end-uses: Once organic waste has been processed, there are limited options for what can be done with it. In some cases, it may be used as a soil amendment or as a source of energy, but there are limited markets for these products.

f) Contamination: Organic waste can be contaminated with other types of waste, such as plastic or metal, which can make it difficult to process. This can decrease the quality of the end product and limit its usefulness.

One promising technique for supporting these goals is vermicomposting, which uses earthworms to break down organic waste into nutrient-rich compost. This process is both cost-effective and environmentally friendly, and it can help to reduce the reliance on chemical fertilizers and pesticides. Vermicomposting also promotes soil biodiversity by providing a habitat for beneficial microorganisms, fungi, and other organisms. This increased biodiversity can improve the overall health of the soil and make it more resilient to disease and other challenges [3]. A consistent supply of organic waste can be difficult to obtain and the lack of infrastructure and inadequate waste management policies can make it challenging to implement vermicomposting projects. Vermicomposting requires careful management and monitoring to ensure the health and well-being of the earthworms and microorganisms involved in the process. Despite these challenges, vermicomposting offers a sustainable and environmentally-friendly solution for waste management. By adopting vermicomposting and other sustainable practices, may support organic farming and waste management in a way that is both sustainable and beneficial for the environment.

Vermicomposting

Vermicomposting is a type of composting that uses earthworms (Figure 1) to break down organic matter into nutrient-rich compost. This process not only produces high-quality compost for plants, but also encourages soil biodiversity by providing a habitat for microorganisms, fungi, and other beneficial organisms. One of the key benefits of vermicomposting is that it creates a balanced ecosystem within the compost pile. This increased biodiversity can improve the overall health of the soil and make it more resilient to disease and other challenges. Additionally, vermicomposting can help to reduce waste by turning food scraps and other organic materials into a valuable soil amendmen [2]. Vermicomposting is characterized as a bio-oxidative process in which earthworms and decomposer microorganisms collaborate to manage organic waste in a way that also helps to improve the physical, chemical, and biological characteristics of soil. This can improve the health and fertility of the soil, making it more hospitable to a wider range of plant and animal species. Earthworms are frequently referred to as "nature's ploughman" or "the farmer's friend." The physical and bio-chemical properties as well as microbiological communities of the soil are affected by earthworms, leading to the production of valuable vermicompost [3]. There are several methods for producing vermicompost, including the following:

Figure 1: Most popular earthworms that have been successfully employed in India to prepare vermicompost.

Batch vermicomposting

This method involves adding organic waste to a container or bin, adding earthworms, and maintaining the conditions necessary for the worms to break down the waste into compost.

Continuous vermicomposting

This method involves adding organic waste to a bin or container on a regular basis and removing the compost as it is produced. This method allows for continuous production of vermicompost.

Windrow vermicomposting

This method involves building a long, narrow pile of organic waste and adding earthworms to break down the waste into compost. This method is often used in large-scale vermicomposting operations.

Vermiculture

This method involves raising earthworms in a controlled environment, such as a worm bin, to produce vermicompost. The worms are fed a diet of organic waste, and their excrement is used as vermicompost.

The choice of vermicomposting method depends on the scale of the operation, the type of organic waste being composted, and the specific goals of the project.

Advantages of Vermicomposting

Figure 2: Advantages of composting with worms.

Vermicomposting is a method of composting that uses earthworms to break down organic matter into nutrient-rich compost. This process enhances soil physical properties and provides plant nutrients and hormones that promote development. Earthworms act as natural bioreactors for the breakdown of organic materials, and vermicomposts are rich in available nutrients and microbial activity. This improves soil fertility, promotes plant development, and reduces the number of plant diseases and pests (Figure 2). Vermicompost is a part of organic farming, and it has been shown to be a remarkable plant growth promoter. The finished product, called vermicast, is also a rich source of hormones and enzymes that help to create a suitable habitat for soil biota [2]. Vermicomposting presents an alternative solution to the problem of burning residue and reduces the negative consequences of improper organic waste management, while producing protein for use in animal feed. Numerous studies have demonstrated that only the African earthworm species, *Eisenia foetida* and *Eudrilus eugenae*, are best for creating vermicompost. The following earthworms shown in Figure 1 are the most popular ones that have been successfully employed in India to prepare vermicompost

Preparation Method

Material required for preparation of vermicompost

Composting requires all biodegradable waste, including cow dung, crop residues, weed biomass, vegetable trash, leaf litter, home waste, hotel waste, waste from agro-industries, and biodegradable components of rural and urban waste. There are five essential commodities for vermicompost (Figure 3 & 4)described below:

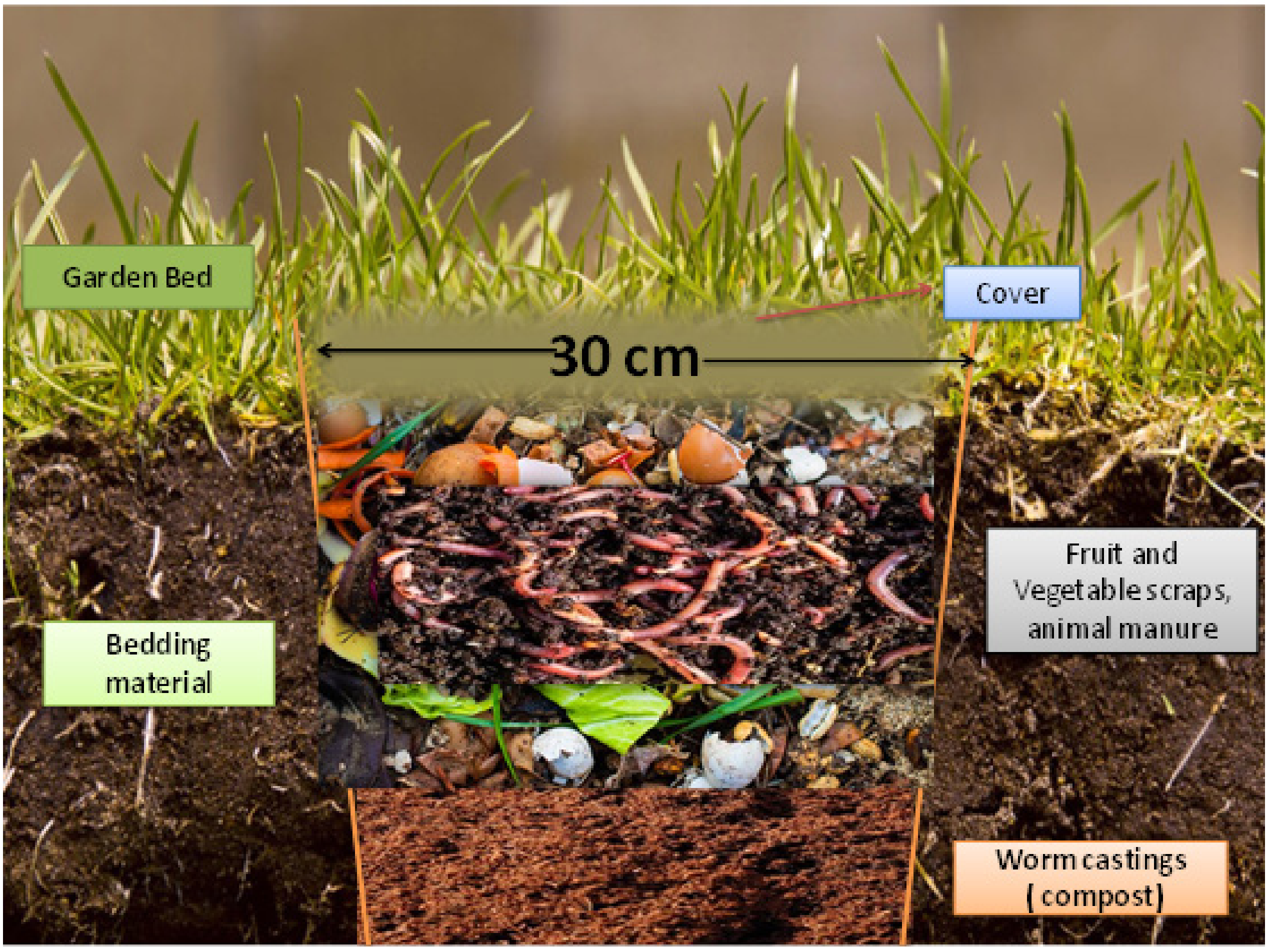

Figure 3: Schematic representation of Vermicomposting.

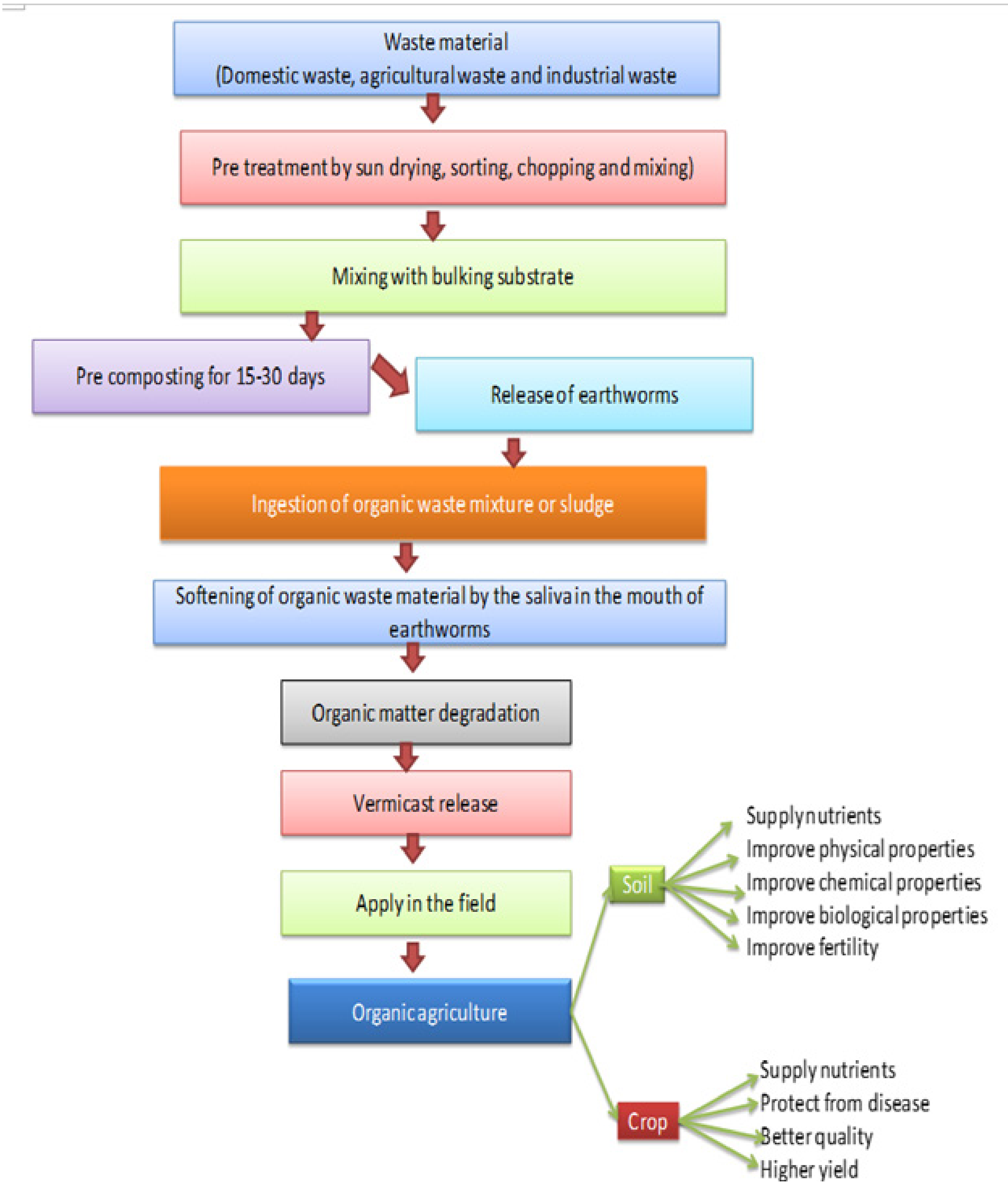

Figure 4: Overview of vermicomposting and related advantage.

Bedding material/organic residues: Any material that offers the worms a habitat that is reasonably stable is considered bedding. Peat moss, corn silage, hay, straw, paper mill sludge, sawdust, shrub trimmings, shredded plant stalks, corn stalks, and corn cobs are a few of the bedding materials that are frequently used. As the worms breathe via their skins and need a moist environment to dwell in, bedding materials should have a high moisture absorption capacity. Although the worms do eat their bedding as it decomposes, it is crucial that this process be gradual. In order to prepare a vermiculture bed or worm bed (3cm), place sawdust, husk, coir waste, or sugarcane waste in the bottom of the tub or container. Over the culture bed, add a layer of fine sand (3cm), then a layer of garden soil (3cm). Water must be used to evenly moisten all layers.

Housing or shed facility: To shield the worms from too much sun and rain, sheltered worm culture is advised. The tanks were made of cement. There was a wall that divided these in half. A second set of tanks was also built for early decomposition. A cement tub can be built up to 212 feet in height and 3 feet in width. Depending on the size of the room, the length may be fixed at any level. To drain the excess water from the vermicompost unit, also known as the vermin wash, the bottom of the tub is designed with a slope-like structure. The drain water needs to be collected in a tiny sump.

Worm food: Earthworms are capable of consuming more than their body weight each day in ideal circumstances. They consume practically any organic food (i.e.,that derived from plants or animals), but dairy and beef manures usually regarded as the greatest natural diet for Eisenia foetida, manures are the most frequently used worm feedstock. Good nutrition is provided by cattle dung, while poultry manure has a high N content, which results in both good nutrition and a high-value product.

Cowdung/biogas slurry: Before using the animal dung to produce vermicompost, it should be dried in direct sunshine. Before depositing any other trash in a vermibed for composting, it should first be predigested with cow dung for twenty days 1kg of worms (1000Nos.) are needed to fill an area of one metre in length, one metre in width, and 0.5 metres in height. There is no requirement that earthworms be placed into the trash. The earthworm will travel independently within.

Watering the vermibed: Vermibed might not need daily irrigation. However, the frequency of watering must be altered based on the surrounding temperature and humidity. However, a 60% moisture level should be kept constant across the time frame. Should the need occur, sprinkle water on the bed rather than pour it on it. Before harvesting vermicompost, watering should be stopped.

Procedure for preparation of vermicompost

The procedure for preparation of vermicompost (Figure 4) is similar in all the methods which is being discussed below;

a. A polythene sheet should be used to cover the cement ring's bottom or the area where vermicomposting will be performed

b. Place a layer of organic trash (15-20cm thick) on the sheet

c. Create a slurry from cow manure

d. Apply a layer of the slurry

e. Layers of material should completely fill the bed

f. Apply dirt or cow manure on the top of the bed

g. Give the material 20 days to break down

h. Release a few earthworms through the cracks after 20 days

i. Use wire mesh or gunny bags to cover the bed to keep birds from stealing the earthworms

j. Water should be sprayed every three days to keep the earthworms' bodies adequately moist and warm.

k. After around two months, check the compost. In 2 to 2 1/2 months, vermicompost will be ready. It has no smell and is light and dark.

l. Remove the compost from the ring and pile it as a cone after it's finished.

m. To allow the earthworms to migrate down the heap gradually, leave the heap undisturbed for two to three hours.

n. Distinguish the top of the stack.

o. Sieve the lower part of the heap to remove the earthworms that can be utilised to make vermicompost once again.

p. Place the bags containing the compost in a cool location.

Diversity of Bacteria Associated with Earthworms in the Indian Himalayan Region

Vermicompost can be used to improve the biological qualities of soil. Recent research has shown that adding vermicompost to soil considerably improves its biological properties, including soil organic carbon, soil microbial biomass, enzymatic activity, population of diverse beneficial microorganisms, hormones, etc. It has been demonstrated that vermicompost has higher dehydrogenase enzyme activity than commercial media, which is a popular method for measuring the respiratory activity of microbial communities. It is anticipated that the activity of earthworm gut bacteria will affect their capacity to boost plant nutrient availability. Earthworms break down the litter and have an impact on the activity of the soil's microflora, which has an indirect impact on the dynamics of soil's chemical processes. Along with rhizospheric soil, earthworms consume plant growth-promoting rhizospheric bacteria like Pseudomonas, *Rhizobium*, *Bacillus*, Azosprillium and *Azotobacter*. Due to the favourable microenvironment of the gut, these bacteria may become activated or increase in number. As a result, earthworm activity raises the quantity of PGPR (plant growth-promoting rhizobacteria). Earthworms boosted the number of microorganisms in soi1 by up to five times, and while travelling through their gut, the number of bacteria and "actinomycetes" present in the ingested material grew by up to 1,000 fold. Numerous anaerobic N_2-fixing bacteria, including *Clostridium butyricum, C beijerinckii* and *C paraputrificum* were present in the gut of *E foetida*. Earthworms improve soil aeration through their burrowing activities, which stimulates and speeds up microbial activity by boosting the population of soil microorganisms, microbial populations, and biomass [5]. In addition to managing solid waste, earthworms are also utilized to treat sewage. Earthworms operate as aerators, grinders, crushers, chemical degraders, and biological stimulators in addition to promoting the growth of "beneficial decomposer bacteria" in wastewater. Vermicomposting, according to reports, transforms infected biomedical waste containing pathogens like Staphylococcus aureus, Proteus vulgaris, Pseudomonas pyocyaneae, and *Escherichia coli* into an innocuous waste containing commensals like *Citrobactor freundii* and aerobic spore bearing microorganism typically found in the soil and alimentary canal of earthworms [6]. Vermicomposts are increasingly being used as biofertilizers because of their exceptional nutritional quality and increased microbial and antagonistic activity [7].

Diversity of Earthworms in Indian Western Himalayas

Earthworm biodiversity has been studied and documented by a number of biologists in different parts of the world. With regard to the western Himalayan states of Jammu & Kashmir, Himachal Pradesh, and Uttrakhand, Paliwal and Julka [8,9] have provided detailed distributional records at the district level, a total of 51 species of earthworms from the western Himalaya that belong to 23 genera and seven families listed in Table 1.

Table 1: Earthworm species of western Himalaya, India [8,9].

Family	Earthworm Species
Moniligastridae	*Drawida japonica*
	Drawida nepalensis
Lumbricidae	*Allolobophora.eiseni*
	Allolobophora parva
Lumbricidae	*Apporrectodea. Caliginosa*
	Apporrectodea caliginosa
	Apporrectodea rosea
Lumbricidae	*Dendrobaena hortensis*
	Dendrobaena. Octaedra
Lumbricidae	*Dendrodrilus rubidus*
Lumbricidae	*Eisenia fetida*
Lumbricidae	*Eiseniella tetraedra tetraedra*
Lumbricidae	*Lumbricus castaneus*
	Lumbricus terrestris
Lumbricidae	*Octolasion cyaneum*
	Octolasion tyrtaeum
Almidae	*Glyphidrilus sps. Gangeticus*
Ocnerodrilidae	*Malabaria levis*
Ocnerodrilidae	*Ocnerodrilus occidentalis*
Ocnerodrilidae	*Thatonia exilis*
	Thatonia gracilis
Acanthodrilidae	*Microscolex phosphoreus*
	Plutellus sadhupulensis
Octochaetidae	*Dichogaster bouaui*
Octochaetidae	*Eutyphoeus annandalei*
	Eutyphoeus incommodus
	Eutyphoeus nainianus
	Eutyphoeus nicholsoni
	Eutyphoeus orientalis
	Eutyphoeus pharpingianus
	Eutyphoeus waltoni
Octochaetidae	*Lennogaster chittagongensis*
	Lennogaster parpus
	Lennogaster pusillus
	Lennogaster yeicus
Octochaetidae	*Octochaetona beatrix*
Octochaetidae	*Ramiella bishambari*

Octochaetidae	*Amynthas alexandri*
	Amynthas corticis
	Amynthas gracilis
	Amynthas morrisi
Octochaetidae	*Metaphire anomala*
	Metaphire birmanica
	Metaphire houlleti
	Metaphire posthuma
Octochaetidae	*Perionyx bainii*
	Perionyx parotensis
	Perionyx excavates
	Perionyx nainianus
	Perionyx sansibaricus
	Perionyx simlaensis

Conclusion

Vermicomposting is one of the efficient and environmentally beneficial methods of waste management that utilizes both earthworms and related bacteria. It has many advantages over conventional composting, including being a great source of biofertilizers that enhance the physiochemical and biological qualities of agricultural soil. Vermicomposting also increases the population and diversity of beneficial microbial populations. However, it is not widely used due to a lack of awareness and technological barriers. Further expansion is needed to fully explore the potential of vermicomposting. This article provides an overview of its characteristics, preparation techniques, advantages, and limitations, as well as its significance in crop development.

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Conflict of Interest

The authors declare that they have no conflict of interests.

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