Review of Recent Developments in Vermicomposting for Agriculture and Environment Applications

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Abstract

Vermicomposting is found to be a sustainable approach for Agriculture and Environment. The germs that cause illness are reduced by 75% by the compost. In addition to boosting nutrients, compost also improves the soil's physical makeup and water-holding ability. It has been discovered that increased soil productivity brought on by the application of VC is reflected in plant growth. According to the type of crops planted and their nutritional needs, the assessment also recommends using Vermicompost at an optimum rate to maximise cost efficiency. Vermicompost generally benefits organic farming and livelihood.

Keywords: Vermicomposting, Natural resources, Soil fertility, Sustainable, Organic farming, Environment, Human race, Organic carbon.

1. Introduction

With increasing the demand of food security, the overburden on the agricultural lands leads to exhaust the nutrient status of the whole globe. The farming activities have led to the depletion of natural resources, decrease soil productivity, soil fertility, flora and fauna and also reduce the amount of soil organic matter, which is crucial for sustaining soil quality as well as agricultural productivity and environmental quality. [1]

To make the agriculture more reliable and cost effective, the concept of modern agriculture along with agro-waste management put forward to managing the soil health. The art of sustainable management of nutrient with agro-waste not only reduce the nutrient deficiency but also manage the soil health along with the management of waste that are produced through agriculture and allied sectors. Organic farming or we can say organic agriculture is a system (uses organic substances for nutrient management e.g., Vermicompost, Farm Yard Manure, Bio-fertilizers) of production that is ecological sustainable and sustains environment and health of soil and human race [1]. This review discusses the ongoing efforts to advance our understanding in assessing the Vermicomposting as a sustainable approach for Environment and evaluating the raw material used

for composting; preparation of Vermicompost, its challenges and opportunities, amendment in agriculture and soil health. Vermicomposting is an eco-biotechnological process of managing the agro & allied carbon based waste. It is a stabilizing and decomposition process of solid organic waste and concentrates the composition of minerals and nutrients with the help of macro & micro-organism viz. earthworms and microbe [2]. Vermicomposting is a stabilization of organic carbon matter through surface dweller species of earthworms mainly *Eisenia foetida, Lumbricus rubellus, Amyanthas diffringens, Eudrillus eugineae, Perionyx escavatus , Lampito mauritii, Drawida nepalensis, Pontocolex corethrurus, Gordiodrilus elegans* etc., which converts the carbon matter into stabilized decomposed matter through decomposition occur in their gut and passes through whole body called as "worm casting". Vermicomposting is a natural, quick and continuous process of composting the organic matter within a span of two to three months. If the populations of worms are high, then the time period of composting reduces accordingly. The main component of good Vermicomposting is that adequate moisture, shade and a good aeration in the compost bed. The turning of compost beds at regular intervals speedy the process of composting. The worm cast is rich in population of several beneficial microorganisms (bacteria, fungi, and actinomycetes) that generate plant-growth-promoting phytohormones (Indole 3acetic acid, Gibberellic acid, and kinetoplast) and enzymes (dehydrogenase, urease) (18, 26). Vermicomposting is a less labour intensive process, one have to maintain the feed, moisture and aeration can manufacture it more easily, remaining work is to be done by the worms itself. Vermicompost is also founded superior than other types of compost due to the amount of microbes and other properties which increase the water holding capacity of soil due to the mucus which is secreted from the worm's bodies. [3]

Vermicompost is an organic biological process of carbon matter feed by earthworms, they converts organic carbon waste viz. agricultural waste (farm yard manure and other agricultural byproducts), municipal waste (better composting on mixing with cow-dung slurry), animal wastes, industrial wastes (free from non decomposable material), sewage sludge, night soil, bio-gas slurry waste into a available nutrient (macro & micro-nutrient) rich compost free from foreign material (on processing). However additional environmental elements such as stocking density, varieties of earthworms, raw material/feed types, and others must be considered in order to preserve the quality of vermicompost (such as temperature, moisture, sunlight, aeration) should be taken into consideration[4] [5].

The soil is where earthworms dwell and eat decomposing organic matter. After being digested, the leftover material travels through the earthworm's alimentary canal and is eventually deposited on the castings as a thin layer of oil. Within a two-month period, this layer erodes. In order to endure longer, plant nutrients are released gradually even when they are immediately available. Organic waste is converted to natural fertiliser through a process that takes place in the earthworm's digestive system. Organic wastes go through deodorising and neutralising chemical transformations. This indicates that the castings are odourless and have a pH of 7 (neutral). In order to continue the process in the soil and encourage microbiological activity, the worm castings also include bacteria. It is similar to composting can be a better option for managing the waste produced and convert it to a nutritional organic substitute for synthetic fertilizer maintaining the environment sustainably. Earthworm castings have been shown by several researchers to possess good aeration, porosity, structure, drainage, and moisture-holding capabilities. The earthworm castings' composition and the natural tillage caused by the worms' burrowing activity increase the permeability of the soil to water. As potential liquid biofertilizer, vermicomposting contains beneficial bacteria and fungus that enriches the soil as well as plant nutrients, plant hormones, and microorganisms (aerobic microorganisms) Arosha, L. and Sarvananda, L. [1].

Ahmed, R. and Deka, H., explored the vermicomposting play an important role in possibility of combining patchouli bagasse (PB) and cowdung (CD) in various treatment ratios for 50 days with Eisenia fetida.They employed the Vermicomposting of patchouli bagasse by Eisenia fetida using essential oil industries.

By examining the potential use of earthworm species in an agronomic environment, it is possible to determine the significance of vermicomposting in sustainable agricultural nutrient recycling, notably nitrogen (N) recovery (76%). The proper management of eco-agricultural system is managed by Vermicomposting (Syed etal.) [3].

Vermicomposting is a sustainable method that requires little upfront expenditure. Vermicompost may be produced in a third as much time as conventional compost. It was discovered that Vermicompost boost a plant's disease resistance. According to the notion, all the bacteria present compete with one another for the nutrients in the soil, making it more difficult for the dangerous germs to thrive. The C/N was significantly lowered to »10 in just 40 days when cow manure and trash from the sugar sector were vermicomposted. Vermicomposting is a sustainable method that requires little upfront expenditure as suggested by Munde etal., [3].

By using earthworms, vermicomposting is a technique for transforming all biodegradable trash into nutrient-rich vermicompost. It enhances the process of using accessible organic and inorganic wastes for composting and other uses during the natural plant production cycle. Vermicomposting is examined from a number of angles, including its potential use in sustainable agricultural systems as explained by Triphathi etal., [12].

Vermicompost (VC) can be used as an alternative to organic fertilisers in organic farming since it enhances soil quality and increases plant development and yield. Nevertheless, the raw materials used in its manufacturing have been recommended to be spiked with a small amount of potentially harmful wastes, like as sewage, to improve soil quality and PGP. It has been discovered that increased soil productivity brought on by the application of VC is reflected in plant growth. VC should be applied at suitable rate based on kind of crops cultivated and their nutritional requirement for cost effectiveness as indicated by Shristi etal., [6]. Earthworms and microorganisms interact during the biological process of vermicomposting, which results in the production of both vermicompost and earthworm biomass. This study conducts a detailed investigation of all the characteristics necessary for vermicomposting, including the design considerations of the surface area for needed pit, needed earthworms types, criteria of selection, and the worms numbers, Sarat Ganti [8]. Quality of Vermicompost prepared from different substrate is given below [6].

2. Vermicomposting and its significance

The Latin term "Vermis," which means "worms," is where the phrase "vermicomposting" originates. The process of converting organic waste into worm castings is known as vermicomposting. It converts biodegradable garbage into vermiculture, a nutrient-rich substance. [7] The soil's fertility depends greatly on the worm castings. High levels of nitrogen, potassium, phosphorus, calcium, and magnesium can be found in the castings. Vermicompost is made by raising earthworms in an environment that is friendly to nature so that they can feed themselves, multiply, and give off their waste, which we refer to as vermicast or earthworm cast. This waste is produced by surface-dwelling worms and is rich in humus and other essential nutrients. By providing these worms with biomass and carefully monitoring the diet (bio-mass).

3. Suitable species of earthworms

The surface-dwelling earthworm alone should be utilised to produce vermicompost. The earthworm, which dwells beneath the soil, is unsuitable for the manufacture of vermicompost.

Three promising worms used to produce vermicompost include the African earthworm (Eudrillus eugenial), Red worms (Eisenia foetida), and the composting worm (Jaygopal). For the creation of vermicompost, all three worms can be combined. Eudrillus eugenial, an African worm, is chosen above the other two varieties because it generates more vermicompost in a shorter amount of time and has younger worms during the composting process.

Figure 1: The above figure depicts *Eisenia fetida*

4. Eisenia fetida

It is also known as a red wiggler worm or a tiger worm. It is a kind of earthworm that is frequently used for vermicomposting due to its many characteristics, including its quick pace of growth and its easy handling nature. (Table 1) (Figure 1) [8]

Table 1 Characteristic features of *Eisenia fetida*

Characteristic features (*Eisenia fetida*)			**Characteristic features (*Dendrobaena veneta*)**	
1	Moisture range	60%-90%	Temperature range	9°C to 30°C
2	Temperature tolerance	Up to 35°C	Moisture content	60% to 85%
3	life cycle	45 to 51 days	Life cycle	100 to 250days

4	Hatching time for sexual maturity	21 to 30 days	Sexual maturity rate	65days
5	Rate of cocoon production	0.4 to 1.3 Cocoonday $^{-1}$	Cocoon rate	0.28 Cocoon day-1
6	Incubation period	18 to 26 days	Hatching viability	20%
7	Life span	4.5 to 5 years	Incubation period	42 days
8	Survival rate at 18°C to 28°C	20 months		
9	Vaibality of Hatching	80.00 %		

5. Dendrobaena veneta

It is also known as the European night crawler and is employed in commercial vermicomposting. It does, however, have certain drawbacks, such as slower rates of maturation and reproduction compared to E. fetida, P. excavatus, and Eeugeniae. [9]

Characteristic features of *Dendrobaena veneta*.

Characteristic features (*Dendrobaena veneta*)		
1	Range of Temperature	9°C to 30°C
2	Content of Moisture	60% to 85%
3	Life Span cycle	100 to 250days
4	Sex based maturity rate	65days
5	Rate of coccon	0.28 Cocoon day-1
6	Hatching property	20%

7	Incubation duration	42 days

Dendrobaena rubida

Although it is uncommon to employ this species since it prefers organic soil, it can be used in vermicomposting [10] (Table 4).

Table 4: Features of *Dendrobaena rubida.*

Characteristic features (*Dendrobaena rubida*)		
1	Life span cycle	75 days
2	Temperature range	15-25°C
3	Maturity based on Sex	54 Days
4	Cocoon production Rate	0.45 Cocoons day-1
5	Hatching	75%

Lumbricus rubellus

Lumbricus rubellus has a slow rate of reproduction and requires a lot of time to develop. Seeing this as a drawback, it is not suitable for vermicomposting. [11] (Table 5).

Table 5: Defining characteristics of Lumbricus rubellus

Characteristic features (*Lumbricus rubellus*)		
1	Life cycle	120-170 Days
2	Temperature range	15°C to 18°C
3	Sexual maturity	71 to 91 days
4	Rate of cocoon production	0.1 Cocoons day-1
5	Maturation time	74-91 days

Perionyx excavatus

Tropics are where you can find it. With its benefit of disintegrating organic materials at high temperatures, Perionyx excavatus is employed in vermicomposting. [12] (Table 6).

Table 6: Defining characteristic of Perionyx excavatus.

Characteristic features (*Perionyx excavatus*)		
1	Life cycle	40-71 Days
2	Temperature range	20°C to 30°C
3	Sexual maturity	55 days
4	Rate of cocoon production	6.7 Cocoons day-1
5	Hatching rate	90%

Many types of earthworms have the capacity to transform organic waste into manure, which is then utilised for waste stabilisation and management. The right earthworm selection, however, is a crucial factor that might impact the speed and quality of decomposition as well as vermiculture.Selection of site for vermicompost production.Worms use for compost are heavy eaters. At favorable conditions, they can consume more than their body weight a day, which is likely to the general thumb rule of half of it. They can eat almost everything that is organic, biodegradable in nature. Manures are the most favorable feed for the worms but they give a good response over other organic matter sources too. Likely to the good source of feed, another main component of Vermicomposting is bedding.

Bedding

Bedding is something that provides relatively a suitable habitat or environment to the worms. This environment must have several characteristics like; it should have high absorbency because worms mostly breathe through their skin and for keeping them alive the bedding material should be keep moist or it should hold appropriate amount of moisture. Besides that, the bedding material should have good aeration, because worms need oxygen to survive, just as we do. Although the worms also consume their bedding as it breaks and decomposed, so it must be low in protein(nitrogen), which can result in rapid degradation and its associated heating.

Different Phases of Vermicomposting process:

Phase 1: It involves the collection of the worm feed or waste material and shredding, mechanical separation of metals, glasses, ceramics and other foreign materials.

Phase 2: The feed should be pre-digestive with dung slurry or water for about 20 days prior to feed to the worms. This process is done to remove the harmful gases from the feed and control the temperature of the feed. Fresh dung should be avoided for bedding.

Phase 3: After pre-digestion, the organic matter is laid down on the worm beds, which should be given a regular check for the moisture and aeration.

Phase 4: Harvesting of vermicompost as the compost process complete which should be monitored through color, odor, decomposition rate and various properties of vermicompost.

Phase 5: After harvesting the vermicompost, a thick layer of some part of vermi-bed containing the good population of earthworms must be feed again with the organic matter and the process repeat from phase 1 onwards.

6. **Vermicompost Harvesting**

The method of composting in tub includes the castings formed at the upper layer should be left open for a period of time so the worms penetrate in lower layer of the bed and the top layer must be scooped out and put in a shady place as heap and the scooping must be restricted up to earthworm presence on the top layer. This harvesting is done periodically and beneficial for maintaining the quality of the compost.

7. **Vermicomposting parameters of consideration**

Temperature: Because it has an impact on the earthworms' development, reproduction, and metabolism, temperature is a crucial factor in vermicomposting. The earthworms became stressed when the temperature dropped below 10°C because they had to stop working and look for a place to survive. In a similar manner, a rise in temperature has an impact on earthworm activity, which lowers their reproductive rate and reduces vermicomposting. Fresh dung balls should be placed in vermin beds in various locations to provide warmth for the worms during cold weather, and watering should be stopped right away. Sprinklers or foggers can be used in addition to watering

the beds when the temperature rises during high temperatures to improve the worms' productivity. 15°C to 30°C is the ideal temperature range, and a thermometer is the measurement tool of choice.

Moisture: Earthworms breathe through their skin and are about 75% to 90% water. If their skin dries up, they will be unable to breathe and will finally die. A substance must be placed to maintain the ideal range of moisture content in order to prevent the moisture content from falling below 60%, which can lower the earthworm breathing rate. It is crucial to maintain the ideal amount of moisture content, hence moisture content must be tested regularly. 70% to 80% moisture is the ideal range.

8. Vermicompost's nutritional value

Vermicompost has different amounts of nutrients depending on the type of waste that is used to prepare it. There will be a wide variety of nutrients in the compost if the waste materials are heterogeneous. Just a limited number of nutrients will be present if the waste is homogeneous. The following are some of the typical nutrients found in vermicompost.

Carbon organic: 9.5–17.98%

Nitrogen content: 0.5% to 1.5%

Phosphorous: 0.10 to 0.30 percent

Potassium content: 0.15 to 0.56%

Salt: 0.06 to 0.30%

22.67 to 47.60 meq/100g for calcium and magnesium

2 to 9.50 mg/kg of copper

Iron: 2.30 to 9.30 milligrammes per kilogramme.

5.70 to 11.50 mg kg-1 zinc

128 to 548 mg kg-1 for sulphate

9. Vermicompost packaging and storage procedures

Vermicompost that has been gathered has to be kept in a cold, dark area. It has to be at least 40% wet. The composted materials shouldn't be exposed to sunlight. Loss of moisture and nutritional content will result. It is recommended that the harvested composted material be kept in open containers rather than over sachets. Packing can be done while selling anything. To maintain moisture levels and a healthy population of good bacteria if it is stored in an open area, occasional watering may be done. When it becomes necessary to store the material, laminated over sacs are packed. This will reduce the loss of moisture through evaporation. Vermicompost may be kept for a year in storage without losing quality.

Advantages of vermicompost

- Vermicompost contains a wealth of all vital plant nutrients.
- Vermicompost is free flowing, simple to apply, handle, and store, and has no unpleasant odour.
- It has good effects on overall plant development, promotes the growth of new shoots or leaves, and enhances the quality and shelf life of the food.
- It reduces soil erosion and enhances soil aeration, texture, structure, and water-holding capacity.
- Vermicompost contains earthworm cocoons, which boosts the population and activity of earthworms in the soil. It is also rich in helpful microflora, including afixers, P-solubilizers, cellulose-decomposing microflora, and other types.It neutralizes the soil protection.
- It includes essential vitamins, enzymes, and hormones like auxins, gibberellins, and other substances that aid in the breakdown of organic materials in soil.

10. Conclusion

The product produced has a high maturity rate and high respiration index, which is a crucial factor in determining the manure's quality. The elimination of disease-causing pathogens in organic waste is an essential objective of vermicomposting. According to reports the organic waste is known to contain 120 virus and bacteria which are harmful to human beings. The compost reduces 75% of the disease causing pathogens. Apart from increasing the nutrients the compost

also increases the physical structure of the soil and the water holding capacity [10]. The literatures cited verify that VC can be used as an organic fertiliser alternative to in organics as it improves soil quality as well as plant growth and production. Moreover, it may be utilised to bioremediate HV-contaminated soil. Nevertheless, the raw materials used in its manufacturing have been recommended to be spiked with a small amount of potentially harmful wastes, like as sewage, to improve soil quality and PGP. It has been discovered that increased soil productivity brought on by the application of VC is reflected in plant growth. According to the type of crops planted and their nutritional needs, the assessment also recommends using VC at an optimum rate to maximise cost efficiency. VC generally benefits organic farming. [5].

11. Future Scope and Prospectus

Many large-scale vermicomposting methods have been utilised over the last ten years with varied degrees of effectiveness. Large-scale vermicomposting may still be in the early stages of development given the amount of time and futile attempts. This shows the need of continuing to evaluate the elements that go into making large-scale systems successful. Poor management, inadequate funding, fabrication of information, issues with regulatory bodies, volatile markets, and newly developing technology that still has to be developed are issues that affect the sector. In some circumstances, system designers anxious to get their products on the market didn't have all the issues ironed out, and in other cases, they didn't give adequate training, which led to subpar management. Several regulatory bodies are unsure about whether to include vermicomposting in the definition of composting or to add a new category with distinct regulations. Yet, the majority of these difficulties are surmountable with the right information and instruction. Due to the fact that potential customers are unfamiliar with the product, marketing vermicompost continues to be difficult. Nevertheless, these issues may be resolved by making study data easily accessible and by educating shoppers, nursery workers, and other members of the public. Vermicomposting found to play a vital role to provide sustainable development.

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