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# Vermitechnology: A review

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**Abstract**
In one year, approximately 700 million organic wastes are generated in India, and this waste is either burned or land filled, posing problem of safe disposal. This problem of waste can be mitigated via converting it into highly valuable nutrient-rich compost in an eco-friendly manner. Vermicomposting is one of the best methods of composting the organic matter, which could provide many solutions to tackle the problem of safe disposal of waste and also provide various micro and macro nutrients to plants for sustainable productivity. In this review article we will discuss various types of vermicomposting, which type is best amongst the other followed by the diversity and advantages of vermicomposting.

**Keywords:** Eco-friendly, organic waste, sustainable, vermicomposting

## Introduction
World's population is increasing day by day, and simultaneously food demand is also increasing significantly which leads to the use of inorganic or the synthetic fertilizers to grow food. These fertilizers have harsh effects on the human health also leads to loss of soil quality and contamination of underground water. Apart from harsh effects, these inorganic or synthetic fertilizers are costly for the farmers which arising the problems due to scarcity of availability in peak seasons (Rajasekaran *et al*. 2012) [14]. The inorganic or synthetic fertilizers are more environment resistant than the natural fertilizers as the inorganic fertilizers are mixed with chemicals, so these are harmful and posing threat to the environment and effects are also observed on soil fertility (Katsunori *et al*. 2003) [9]. In this context the awareness should be created among the farmers regarding the use of organic fertilizers.
Organic fertilizers include biofertilizers and vermicompost which are rich source of micro, macro and secondary nutrients to sustain the soil fertility. In the present review methods, procedures and the applications of vermicomposting will be discussed. It refers to composting or natural conversion of biodegradable garbage into high quality manure with the help of earthworms (Fig 1). Earthworms serve as versatile natural bioreactors to harness energy and destroy soil pathogens. These worms do so by feeding voraciously on all biodegradable refuse such as leaves, kitchen waste, vegetable refuse etc. (Mishra *et al*. 2012) [12]. These organic manures may provide nutrients for the micro-organisms present in soil. Thus, *via* increasing microbial activities in the soil these help in conversion of unavailable plant nutrients into available form for promotion of plant growth. Hence the use of organic fertilizers might be considered rapidly replacing the use of inorganic fertilizers.

## Vermitechnology
It is a collective term used for the methods in which wastes are converted into useful products through the action of earthworms which mainly comprises: -

## Vermiculture
It is the science of breeding and raising earthworms naturally by maintaining the environmental balance without any adverse effect. It is being tested for treatment of industrial, agricultural, sugar and food processing wastes (Kale 2000) [8]. This technology is more economically viable, environment friendly, efficient and practically feasible for recycling process, which involves the use of earthworms for effective recycling of non-toxic organic solid and liquid wastes in the soil. It can be used for the management of weeds and wastes from kitchen, agriculture, industries etc. (Frederickson *et al*. 1997; Kale 1993; Sinha *et al*. 2002) [6, 7, 17].

**Fig 1:** Showing earthworm (*Eisenia fetida*)

**Fig 2:** Showing vermicompost prepared by *E. fetida*

**Vermicomposting**

The term vermicomposting has been coined from the Latin word 'Vermis' meaning to the 'worms', and composting which refers to controlled bio-oxidation of waste material into compost or natural conversion of biodegradable garbage into high quality manure with the help of earthworms that reduces the environmental risk by transforming the material into a safer and more stable product suitable for application to soil (Lazcano *et al*. 2009) [10]. It allows obtaining organic sources of nutrients which are physically, nutritionally and biochemically improved (Chaudhary *et al*. 2004) [4].

**Vermiconservation**

Which is mass maintenance and rectification of waste lands with the help of earthworms (Ansari and Ismail 2012) [1]. These waste lands are having poor soil structure, low soil fertility and less production.

**Types of vermicomposting**

On the basis of amount of production and composting structures, vermicomposting is of two types:

1. **Small-scale vermicomposting:** It is done to meet the personal requirement, in this farmer can harvest 5-10 tonnes of vermicompost annually.
2. **Large-scale vermicomposting:** It is done at commercial scale by recycling large quantity of organic waste with the production of > 50-100 tonnes annually.

**Methods of Vermicomposting**

There are mainly five types of methods of vermicomposting, which are as follow:

**Pit method**

In this method a bed of size 10 x 1 x 0.3 m (Fig. 3) is required and this bed initially, should be treated with chlorpyriphos (@2ml/lt water) to prevent termite and ant problem. After 15 days, this bed will be filled by various layers of organic residues, *i.e.*

1. First layer will be of decomposable plant material (*i.e.*, bottom of the bed).
2. Second layer will consist of either cow dung or biogas sludge.
3. In third layer earthworms will be spread (approximately 1000-2000 in number).
4. Fourth layer again consist of either cow dung or biogas sludge.
5. Fifth layer will be either dry crop residue or green succulent leafy material along with cow dung.
6. In Sixth layer a thick layer of mulch with cereal straw will be spread (*i.e.*, top of the bed).

**Fig 3:** Showing bed for Pit method of vermicomposting

**Heap method**

For this method of vermicomposting a levelled ground is required on which waste material is spread and covered with cattle dung. This levelled ground should be free from glass pieces, stones and should be uniform with dimension 1m width, 0.30 m height, and length of the heap may vary according to the organic waste and dung. Organic waste and cow dung should be spread over the ground to a height of 15 cm, moistening of this layer also should be done. After that earthworm collected from the local field will be released in the heap. Watering should be done daily to earthworm bed. Earthworms will eat the waste and cow dung and excrete excreta in the form of heaps. These heaps will be removed weekly and dried in the shade as before. After drying it is known as vermicasting as it is very rich in nutrients. 1 kg of earthworms can produce 10 kg of vermicasting within 45-60 days.

When we compare the efficacy of pit and heap methods of preparing vermicompost under field conditions by considering the biodegradation of wastes as criterion, heap method of vermicomposting is better than the pit method. Earthworm population was found to be high in heap method when compare to pit method as 21-fold in heap and in pit 177-fold. Biomass production was also higher in heap method i.e., 46-fold and 31-fold in pit method. 51 kg vermicompost is produced by heap method and 40 kg with pit method (Sunitha *et al*. 1997) [21].

**Wooden box or brick column**

For this method columns are required which are made up of normal bricks, hollow bricks, asbestos sheets, shabaz stones and locally available rocks. The dimensions of the column are evaluated by ICRISAT as 3 m width, 1 m length and 1 m height. These columns are erected above the ground level and are dumped with the organic material serially as in earlier

methods. Watering should be done regularly to maintain 60-80% moisture level until the compost harvesting.

**Cement rings**

Cement rings can also be used to prepare vermicompost above the ground. The size of the cement ring should be 90 cm in diameter and 30 cm in height.

**Commercial model**

For this method columns are required which are made up of normal bricks, hollow bricks, asbestos sheets, shabaz stones and locally available rocks. The dimensions of the wall separating these columns are evaluated by ICRISAT as 1.5 m width, 4.5 m length and 0.9 m height (Fig. 4). Small holes are present at the partition wall of commercial biodigester which facilitates easy movement of worms between the columns. An outlet should be provided at one corner of each chamber with a slight slope which facilitates collection of excess water, which can be reused later or used as earthworm leachate on crop. The outline of the commercial model is given in fig. These columns are filled with plant residues or organic waste one after another.

1. The first chamber is filled layer by layer along with cow dung after that earthworm are released.
2. The second layer is also filled layer by layer. After processing of contents in first chamber, the worms move to second chamber which is already ready for worms as filled with residues. This method of vermicomposting has advantages as it saves labor for introducing and harvesting earthworms and reduces water, time as well as labor cost.

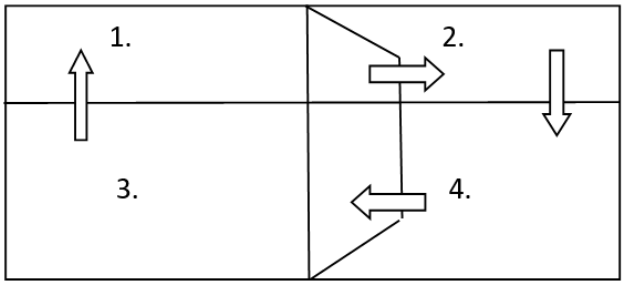


**Fig 4:** Showing diagrammatic representation of the commercial model with four chambers for vermicomposting

**Process of vermicomposting**

The entire process of vermicomposting is as follow:

For the process of preparation of vermicompost earthworms and other biodegradable wastes are required mainly to add nutrients to the soil (Table 1). Compost is a natural fertilizer that allows an easy flow of water to the growing plants. The earthworms are mainly used in this process as they eat the organic matter and produce castings through their digestive systems.

**Table 1:** Nutrient profile of vermicompost

| **Nitrogen** | **1.6%** |
|---|---|
| Phosphorus | 0.7% |
| Potash | 0.8% |
| Calcium | 0.5% |
| Magnesium | 0.2% |
| Iron | 175 ppm |
| Manganese | 96.5 ppm |
| Zinc | 24.5 ppm |
| C:N ratio | 15.5 |

**Materials required**

Water, cow dung, earthworms, gunny bags, thatch roof, soil or sand, weed biomass, a large bin (plastic or cemented tank), dry straw and leaves collected from paddy fields, biodegradable wastes collected from fields and kitchen.

**Procedure**

1. To prepare compost, either a plastic or a concrete tank can be used. The size of the tank depends upon the availability of raw materials.
2. Collect the biomass and place it under the sun for about 8-12 days. Now chop it to the required size using the cutter.
3. Prepare cow dung slurry and sprinkle it on the heap for quick decomposition.
4. Add a layer (2 – 3 inch) of soil or sand at the bottom of the tank.
5. Now prepare fine bedding by adding partially decomposed cow dung, dried leaves and other biodegradable wastes collected from fields and kitchen. Distribute them evenly on the sand layer.
6. Continue adding both the chopped bio-waste and partially decomposed cow dung layer-wise into the tank up to a depth of 0.5-1.0 ft.
7. After adding all the bio-wastes, release the earthworm species over the mixture and cover the compost mixture with dry straw or gunny bags.
8. Sprinkle water on a regular basis to maintain the moisture content of the compost.
9. Cover the tank with a thatch roof to prevent the entry of ants, lizards, mouse, snakes, etc. and protect the compost from rainwater and direct sunshine.
10. Have a frequent check to avoid the compost from overheating. Maintain proper moisture and temperature.

**Biodiversity in vermicompost**

Coleman (1985) [5] and Bohlen *et al*. (2004) [3] have noted that the earthworms play a very important role in affecting soil organisms' population especially causing changes in soil microbial. Nagavallemma *et al*. (2004) [13] found higher microbial population in partially decomposed dry organic waste material for vermicompost ($69\times10^6$ CFU/g bacteria; $11\times10^4$ CFU/g fungi; $2\times10^4$ CFU/g actinomycetes) as compared to that of vermicompost ($54\times10^4$ CFU/g bacteria; $8\times10^4$ CFU/g fungi; $1\times10^4$ CFU/g actinomycetes). It happened may be due to existing pH and temperature of partially decomposed raw material. Subler *et al*. (1998) [20] compared vermicompost and thermophilic composts and observed that vermicompost is much richer in microbial diversity, population and activities.

The epithelium of digestive tract of worms is known to secrete amylase, invertase, cellulase, phosphatase and protease (Ranganathan and Vinotha 1998) [15]. Earthworms inevitably consume the soil microbes during the ingestion of soil and litter. Sterilized and Sterilized, 2000 [19] estimated that earthworms necessarily have to feed on microbes, particularly fungi for their nitrogen/protein requirement, which may be the reason of less diversity of microorganisms in the vermicompost.

In vermicompost *Trichoderma* and *Penicillium* are found which possess antibiotic activities which can be used as biological control on soil borne pathogens. Szczech *et al*. (1993) [22] investigated that vermicompost helps in suppression of soil borne plant pathogens. Stephens *et al*.

(1994) [18] found disease suppression in the presence of earthworms. Disease suppression by vermicompost has been attributed to activities of antagonistic or competitive microorganisms as well as the antibiotic compounds present in vermicompost.

**Result**

After the 24th day, around 4000 to 5000 new worms are introduced and the entire raw material is turned into the vermicompost.

**Application of vermicomposting**

Vermicompost has wide application in the field of agriculture.

a. It can increase both the yield of crops and also the other component of plants like cob weight, leave production, height, and weight. The application of vermicompost as organic farming is the future of Indian agricultural technology (Ayoola and Makinde 2009) [2].
b. Organic wastes returned in soil as vermicompost contribute to reduce the fertilizer's requirement of crop.
c. It can be used as a potting mixture for horticultural crops (Roychowdhury *et al*. 2017) [16].
d. It improves physical properties such as bulk density, porosity, aggregate formation, porosity and hydraulic conductivity (Lee *et al*. 2018) [11].
e. It has high porosity, aeration, drainage and water holding capacity which could improve soil texture and water-holding capacity of the soil.
f. Vermicomposting is gaining interest as a sustainable alternative in treating organic waste, such as sludge.

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