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Vermicomposting: An Effective Option for Recycling Solid Wastes into Organic Fertilizers

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Abstract

Effective management of solid waste, generated as a result of rapid urbanization and industrialization, has now become one of the major problems. Overproduction, improper disposal methods including imbalanced and untimely application of solid wastes in agricultural fields ultimately leads to environmental pollution. But these organic wastes can be utilized for vermicomposting, an effective recycling technique, which can produce a disinfected, detoxified, highly nutritive, superior quality end product by proper handling. Here, cooperative action of earthworms and microorganisms takes place to transform biodegradable wastes into valuable organic fertilizer called vermicompost which is a rich source of humus, macro and micronutrients; beneficial soil microbes including nitrogen-fixing, phosphate solubilizing bacteria, actinomycets; growth hormones including auxins, gibberellins and cytokinins. Therefore, vermicomposting not only results in effective solid waste management but also provides excellent nutrient rich vermicompost, a suitable supplement to chemical fertilizers that is beneficial to promote sustainable organic farming and maintaining ecological balance.

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Introduction

In this present context adoption of ecological and sustainable farming practices is the only way to reverse the global carbon concentrations and environmental degradation trends. Massive solid waste accumulations have resulted in major environmental issues due to burgeoning population, urbanization, industrialization and agricultural production. Alteration and safer disposal of this solid waste is the urgent necessity for maintaining soil health and pollution free environment. In this journey, vermicomposting is the most effective solid waste management technique which places a marked impression as an eco-friendly procedure to convert a wide range of wastes into valuable organic fertilizer, promoting pollution free soil and environment. Vermicomposting is generally a mesophilic process involving a combined action of earthworms and mesophilic microorganisms to convert organic wastes into valuable end product known as vermicompost which is a rich source of readily available nitrates, soluble phosphorus, exchangeable potassium, calcium, magnesium including micronutrients such as zinc, copper, iron, manganese etc. it also contains beneficial soil microbes including nitrogen fixing and phosphate solubilising bacteria and actinomycetes as well as acts as an excellent growth booster and protector for crop plants as compared to regular compost.

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Earthworms and Their Role in Vermicomposting

Eminent personalities like Charles Darwin and Aristotle described earthworms as the 'unheralded soldiers of mankind', and the 'intestine of earth', respectively as they could break down a wide range of organic material (Olle, 2019).

Earthworms have been classified into three categories based on their morpho-ecological characteristics:

Anecic ("out of the earth", Greek word) - These are the burrowing earthworms that only come to the surface at night to drag food down into their deep vertical burrows (20-30 cm long) within the mineral soil layers; *e.g.*, *Lumbricus terrestris*.

Endogeic ("within the earth", Greek word) - These are also burrowing worms living in typically shallower burrows. These worms feed on the organic matter inside the soil and rarely come to the surface.

Epigeic ("upon the earth", Greek word) - The worms normally reside on the surface litter and consume decaying organic matter.

Two tropical species such as African night crawler, *Eudrilus eugeniae* (Kinberg) and Oriental earthworm, *Perionyx excavates* (Perrier) and two temperate species including red earthworm, *Eisenia andrei* (Bouche) and tiger earthworm, *Eisenia fetida* (Savigny) are widely used in vermicomposting due to their high consumption rate, ability to digest and assimilate organic matter, tolerance to variable environmental factors, high reproductive ability as well as flexibility during handling. Apart from these, species like *Drawida nepalensis*, *Lampito mauritrr*, *Dichogaster* spp., *Polypheretima elongate, Amynthas* spp. *Dendrobaena octaedra, Eisenia hortensis* have also been utilized for composting under certain specific conditions.

Earthworms mainly act as a grinder, crusher, biological stimulator and chemical degrader of waste material promoting favourable growth of certain decomposer aerobic bacteria present in organic waste material. In addition to that, earthworms act as the host of several hydrolytic enzymes and hormones that help in rapid decomposition of complex organic matter to convert it into simple vermicompost within 1-2 months, which takes at least 5 months in regular composting. Only 5-10% of the consumed material is engaged for the growth of worms and the rest is excreted as vermicast which is an excellent organic fertilizer and soil conditioner. Vermiwash, a liquid fertilizer, can be produced from the passing water through the columns of vermiculture beds and can be applied as a foliar spray. The vermicompost formation by earthworms takes place in following steps: (i) consumed organic material is softened by the secreted saliva from the mouth of earthworms; (ii) further food softening in esophagus and physical breakdown of food in muscular gizzard resulting in < 2 µ particles size; (iii) finely ground food material is then exposed to several enzymes secreted in lumen by stomach and small intestine. The microbes present in small intestine facilitate break down of complex food materials into simpler compounds.

Common Methods of Vermicomposting

There are three commonly used methods for vermicomposting discussed under the following heads:

i) Bin Composting

• Used for small scale vermicomposting.

• Bins can be made of wooden, plastic or recycled containers like bathtubs and barrels.

• Bins may be of different shapes and sizes but average dimension is 45 × 30 × 45 cm^3. Around 10 holes of 1-1.5 cm diameter in bottom, sides and cap of bin is beneficial for proper drainage and aeration.

ii) Pit Composting

• Used for large scale vermicomposting.

• Bottom and sides of the pit should be made with a wooden staff.

• Pits of 2.5 × 1 × 0.3 m^3 under sheds with open sides are advisable.

iii) Pile Composting

• For large scale vermicomposting.

• Piles can be made in greenhouse or floor with good drainage provision.

• Pile size may vary in length and width. Advisable height of pile should be as like the average height of bin used for bin composting.

Steps Involved in Vermicomposting

Vermicompost in large scale is mostly prepared by using either pit or heap/ pile method. Pre-digestion (thermophilic composting) of organic wastes prior to vermicomposting for a shorter duration is highly preferable to facilitate volume reduction and waste stabilization. After some days, a thin layer of pre-prepared compost is spread on vermicomposting beds. Several agricultural residues with high C:N ratio including dry wastes, soybean stover, sorghum and wheat straw, pigeon pea stalks, groundnut husk, vegetable wastes, weeds (*e.g.*, *Parthenium*) before flowering as well as animal manures, poultry and dairy wastes, wastes from food industry, municipal solid wastes *etc*. also come to be promising raw materials for vermicomposting. Vermicompost preparation can be done at any place having shades and high humidity.

Pre-Digestion of Organic Waste Material

• It should be done at least 20-25 days prior to vermicomposting by mixing organic wastes along with cow dung slurry.

• Regular watering is advisable for partial decomposition to make that fit for consumption by earthworms.

• Raw materials such as cow dung, crop residues, farm wastes, vegetable market wastes and fruit wastes can be used for composting. Acid-rich substances like citrus wastes should be prohibited.

Preparation of Earthworm Bed

Bedding material generally provides a relatively secure habitat to the earthworms. Bedding material should be with high absorbing ability, good bulking potential and high C:N ratio. Bedding must have high absorbency to retain water as earthworms normally breathe through their skins. If skin dries out worms dies. As the worms respire aerobically, avoid too dense or tightly packed bedding materials that reduce or restrict the air flow. Moreover, organic wastes with more carbon content is desirable as the earthworms and microbes present in the feed mixtures activate microbial respiration as well as involve in decomposition of organic wastes that ultimately accelerate the loss of organic carbon during vermicomposting. Preferable environmental conditions for earthworms are given in table 1.

Table 1: Preferable environmental conditions for earthworms in composting (Singh *et al*., 2022)

Parameters	Optimum condition
Temperature	18-35 °C
Moisture content	60-70%
Aerobicity	40-50% (from the total pore space)
pH	6.5-7.5

Preparation of Vermiculture Bed

Preparation of vermiculture bed can be done by using saw dust, straw, newspaper, sugarcane trash, coir waste *etc*. as a first layer at the bottom of pit/ container. A second layer of moistened fine sand (3 cm) followed by a layer of garden soil (3 cm) should be placed over the culture bed. To prevent migration of earthworms into the soil unit floor should be compacted.

Addition of Organic Waste Materials and Vermiworms for Composting

Prepared pre-composted organic waste material is added at the third layer. Thin layer of cow dung slurry is spread over the waste material surface that serves as starter food for worms. After that, vermiworms have to be added. Covering should be done with gunny bags. Wait for at least 15 days after addition of pre decomposed organic wastes to complete thermophillic process as there is a rapid increase in temperature followed by a gradual decrease. 2-3 times turning of material at an interval of 4-5 days is advisable. It is desirable to maintain temperature at 30 °C. Upturning with regular water sprinkling is advisable for proper temperature maintenance. The vermicompost is expected to be completely prepared within 45-60 days depending upon temperature, moisture content and used raw materials. The final product is free from bad odour if right bedding/ feeding material is used and has characteristics black colour with light weight. Earthworms can reduce 40-60% volume by consuming various organic wastes equivalent to its body weight and can produce cast about 50% of the consumed wastes (in a day).

Harvesting of Vermicompost

Make a heap on a plastic sheet in sunlight and leave it for at least 1-2 hours. The worms will settle down at the bottom of heap. Collect the vermicompost from top as well as carefully gather the settled down worms from the bottom for next batch of vermicomposting.

Preventive Measures during Vermicomposting

• Avoid plastic sheets to cover vermicompost beds/ heaps as it may entrap heat and gases.

• Avoid overloading of vermicompost beds/ heaps to minimize extreme heat generation which affects population and activity of earthworms adversely. 18-25 °C temperature should be maintained for well decomposition of wastes.

• The earthworms need to be protected from direct sunlight, termites, birds, ants and rats.

• Adequate moisture content with good drainage provision should be maintained during the entire process as excessive moisture fluctuation may cause death of earthworms or reduce their activities. Avoid water stagnation particularly in high rainfall areas during rainy season.

• Proper aeration should be maintained for proper growth and multiplication of earthworms.

• Solid waste materials used for composting should be free from any non-degradable inert materials such as stones, plastics, glass pieces *etc*.

• Cover the bed/ heap with gunny bags to make darkness as well as maintaining moisture level in beds.

• Cow-dung should at least be 15-20 days old to avoid extreme heat generation.

Role of Vermicompost in Organic Agriculture

Vermicompost, popularly known as black gold is now becoming one of the major components of organic farming system. Vermicomposting provides a superior-quality end product (vermicompost) than regular composting

due to combined activity of earthworms, enzymes and microbes during the entire process enabling biological conversion of wastes into organic fertilizer. The decomposed waste material passes through the guts of earthworm, thereby, enrich the earthworm cas tings in microbial activity, plant growth regulators as well as provide pest repellence attributes. Moreover, vermicomposting takes shorter processing time resulting in mass reduction and also provide valuable end product with high humus content including low phytotoxicity levels. Thus, vermicompost is considered as ideal nutrient rich manure for organic farming due to high porosity, high water-holding capacity, better aeration, high humus level including plant growth hormones namely cytokinins and auxins, enzymes, certain metabolites including vitamin B, vitamin D and similar substances that are able to suppress certain pests and disease occurrence. The nutrient status of vermicompost obtained from various organic wastes has been given in table 2.

Table 2: Available nutrient status in vermicompost

Nutrient element	Availability in vermicompost
Organic carbon	9.15-17.88%
Nitrogen	0.5-0.9%
Phosphorous	0.1-0.26%
Potassium	0.15-0.256%
Sodium	0.055-0.3%
Calcium and Magnesium	22.67-47.6 (Meq 100 g^{-1})
Copper	2-9.5 mg kg^{-1}
Iron	2-9.3 mg kg^{-1}
Zinc	5.7-9.3 mg kg^{-1}
Sulfer	128-548 mg kg^{-1}

*These values are subjected to change depending upon the waste material used (Source: Garg and Gupta, 2009)

Application of Vermicompost

• Field crops: Around 3-4 t ha^{-1}. Applied as basal or top-dressing in standing crop based on requirement.

• Fruit trees: 5-10 kg $tree^{-1}$ depending upon the age of the plant.

• Vegetables: Around 3-4 t ha^{-1}. Should be applied in the nursery bed for healthy and vigorous seedlings.

• Flowers: 500-750 kg ha^{-1}.

Advantages of Vermicompost

• Application of vermicompost substantially improves soil structure, fertility, aeration, prevents soil erosion and suppresses soil-borne diseases.

• Being a rich source of all essential nutrients including vitamins, enzymes and growth hormones, application of vermicompost can provide healthy plant stand.

• Vermicompost influence the microbial population and their activities which in turn increases the nutrients availability through N fixation and P solubilization.

• Application of vermicompost results in better nodulation in legumes and improves symbiotic mycorrhizal associations with the roots.

• Being an eco-biotechnological and low cost waste management technique, vermicomposting can be a useful cottage industry that can provide supplementary income to underprivileged and economically weaker sections.

Conclusion

To protect human health from the harmful effects of chemical fertilizers and to preserve the agro-ecosystem the new emerging concept of 'Ecological Agriculture and Organic Farming' has to be promoted that mainly focuses on production of chemical free foods. Organic farming using various organic fertilizers like "vermicompost" can be an effective substitute of chemical fertilizers that can not only minimize the economic cost but also may lead to organic products fetching higher market value.

References

Garg, V.K., Gupta, R., 2009. Vermicomposting of agro-industrial processing waste. In: *Biotechnology for Agro-Industrial Residues Utilisation*, (Eds.) Singh nee' Nigam, P., Pandey, A. Springer, Dordrecht. pp. 431-456. DOI: 10.1007/978-1-4020-9942-7_24.

Olle, M., 2019. Review: Vermicompost, Its Importance and Benefit in Agriculture. *Journal of Agricultural Science* 2, 93-98. DOI: 10.15159/jas.19.19.

Singh, R., Bairwa, R.K., Singh, M., 2022. Vermicomposting: Recycling Solid Waste into Organic Fertilizer. *Intensive Agriculture* 56(3), 4-6.