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Organic Waste Management By Vermitechnology

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Abstract: *Vermitechnology has become a popular method for the safe disposal and cost effective treatment of diverse organic wastes for the production of Vermicompost and worm biomass. It is an environmental friendly, rural based technology for sustainability as it process diverse organic wastes in the nature, avoids pollution through recycling of plants nutrients. The disposal of organic wastes in unscientific manner causes many more problems such as fly breeding, transmission of pathogenic microorganisms, soil and air pollution. Earthworms as considered as natural bioreactors, which proliferate along with saprophytic micro-organisms, provide necessary conditions for the bio-processing of organic wastes. Hence, the review assesses the significant role of earthworms through vermitechnology in management of organic wastes and sustainability of environment and their future prospects. The product like vermicompost and vermiwash in the form of organic fertilizer and bio pesticide helps to improve physic-chemical and biological parameters of soil and acts as a soil conditioner that indirectly increase food production and soil health.*

Key words: *Vermitechnology, vermiculture, vermicompost, organic waste.*

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I. Introduction

Solid waste management is essential to maintain healthy environment in the nature. There are many problems in the environment concerned with high production and accumulation of large amount of organic wastes. Indiscriminate spreading of these organic wastes can cause soil and water pollution ultimately leads to soil fertility damage and health problems. These environmental problems can be avoided, if these organic waste materials are pre-porcessed before their disposal into the nature. To process these wastes aerobic biodegradation is must for safe disposal so as to produce good quality processed product. The natural process of breakdown of organic wastes by saprophytic microorganisms can be doubled by using special varieties of earthworms through the process known as Vermitechnology.

Vermitechnology is a combination of both vermiculture and vermicomposting. It is a process of composting organic wastes into valuable organic fertilizer by the action of earthworms. It is an effective, eco-friendly, cheap and easy method for recycling of biodegradable organic wastes using selected species of. It is a cost effective, efficient, safe disposal of all kinds of organic wastes apart from producing very useful product called vermicompost [1].

2.1. Vermiculture

Vermiculture defines the rearing of special types of earthworms such as epigeic and anecic types, which involves multiplication of earthworms stock by providing optimum environmental conditions such as proper moisture, temperature and sufficient food etc. Vermicomposting involves bio-oixdation and stabilization of organic wastes through the interaction between earthworms and microorganisms [2]. Earthworms play an important role in the fragmentation process and providing substrate so as to increase the surface area for growing micro-organisms.Vermitechnology has become a popular method for the safe disposal and cost effective treatment ofdomestic and agricultural organic wastes, Since, 2010 remarkable work have been published in organic waste management and research on this technology for the transformation of energy rich organic matter into humus like product ‘vermicompost’.

Three main ecological groups of earthworms, based on the soil horizons in which the earthworms were commonly found *i.e.,* litter, topsoil and sub soil have been recognized [3]. Epigeic Earthworms have been classified in several ways; perhaps the most useful is based on their behavior and habitat. They developed a classification that divides worms into the following three categories: epigeic, endogeic and anecic.

- Epigeic – (Greek for “out of the earth”) types live at the surface in freshly decaying plant or animal residues. They do not have permanent burrows. They are phytophagous, very small in size, very active and have regenerative capacity within short period of time, richly pigmented worms. These types of decomposers are used in Vermicomposting. *Eg. E.foetida, E.eugenia and P.excavatus.*

- Endogeic – (Greek for "within the earth") types live underground and eat soil to extract nutrition from degraded organic residues. They have intermediate life cycles with limited regenerative capacity and small to large in body size. They are geophagous. *Eg. Metaphire posthuma and Octochaetona thurstoni.*
- Anecic – (Greek for "out of the earth") types burrow deep in the soil but come to the surface at night to drag food down in to their permanent burrows deep within the mineral layers of the soil. The body size slightly pigmented at anterior and posterior end. They are phytophagous in nature *E*g. *Lumbricus terrestris*

2.2. Vermicompost

Vermicompost is an aerobically degraded rganic matter. It is also called as "Black Gold", it is a granular, aggregate, coated with muco-polysaccharides of microbes and earthworms [4]. The vermicompost contains humified organic matter characterized by high molecular weight and an enzymatically active humic fraction, which stimulates plant germination and growth [5]. The nutrient present in the casts are readily soluble in water and are rich sources of macro and micro nutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora [6]. Vermicompost is rich in available plant nutrients such as N, P, K, Ca, Mg, S and micronutrients like Fe, Zn, Mn, Cu etc. The Vermicompost has many more plant growth hormones and rich in saprophytic microorganisms.

2.3. Vermicomposting Methods

Vermicomposting is the biological degradation and stabilization of organic waste by earthworms and microorganisms to form vermicompost. This is an essential part in organic farming today. It can be easily prepared, has excellent properties, and is harmless to plants. The earthworms fragment the organic waste substrates, stimulate microbial activity greatly and increase rates of mineralization. These rapidly convert the waste into humus-like substances with finer structure than thermophilic composts but possessing a greater and more diverse microbial activity. Vermicompost being a stable fine granular organic matter, when added to clay soil loosens the soil and improves the passage for the entry of air. The mucus associated with the cast being hydroscopic absorbs water and prevents water logging and improves water holding capacity. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb these nutrients. The soil enriched with vermincompost provides additional substances that are not found in chemical fertilizers [7].

Vermicomposting offers a solution to tonnes of organic agro-wastes that are being burned by farmers and to recycle and reuse these refuse to promote our agricultural development in more efficient, economical and environmentally friendly manner.

Methods of Vermicomposting

(1) Pits below the ground

Pits made for vermicomposting are 1 m deep and 1.5 m wide. The length varies as required.

(2) Heaping above the ground

The waste material is spread on a polythene sheet placed on the ground and then covered with cattle dung. The efficacy of pit and heap methods of preparing vermicompost under field conditions was compared [8]. Considering the biodegradation of wastes as the criterion, the heap method of preparing vermicompost was better than the pit method. Earthworm population was high in the heap method, with a 21-fold increase in *Eudrilus eugeniae* as compared to 17-fold increase in the pit method. Biomass production was also higher in the heap method (46-fold increase) than in the pit method (31-fold). Consequent production of vermicompost was also higher in the heap method (51 kg) than in the pit method (40 kg).

(3) Tanks above the ground

Tanks made up of different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks were evaluated for vermicompost preparation. Tanks can be constructed with the dimensions suitable for operations. The tanks with dimensions of 1.5 m (5 feet) width, 4.5 m (15 feet) length and 0.9 m (3 feet) height. The commercial bio-digester contains a partition wall with small holes to facilitate easy movement of earthworms from one tank to the other.

(4) Cement rings

Vermicompost can also be prepared above the ground by using cement. The size of the cement ring should be 90 cm in diameter and 30 cm in height. The details of preparing vermicompost by this method have been described in a later section.

(5) Commercial model

The commercial model for vermicomposting consists of four chambers enclosed by a wall (1.5 m width, 4.5 m length and 0.9 m height). The walls are made up of different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks. This model contains partition walls with small holes to facilitate easy movement of earthworms from one chamber to another. Providing an outlet at one corner of

each chamber with a slight slope facilitates collection of excess water, which is reused later or used as earthworm leachate on crop. The four components of a tank are filled with plant residues one after another. The first chamber is filled layer by layer along with cow dung and then earthworms are released. Then the second chamber is filled layer by layer. Once the contents in the first chamber are processed the earthworms move to chamber 2, which is already filled and ready for earthworms. This facilitates harvesting of decomposed material from the first chamber and also saves labor for harvesting and introducing earthworms. This technology reduces labor cost and saves water as well as time.

Characteristic of earthworm species suitable for Vermicomposting

The role of earthworms in organic solid waste management has been well established since first highlighted by Darwin (1881) [9] and the technology has been improvised to process the waste to produce an efficient bio-product vermicompost [10-12]. Epigeic earthworms like *Perionyx excavatus*, *Eisenia fetida, Lumbricus rubellus* and *Eudrilus eugeniae* are used for vermicomposting but the local species like *Perionyx excavatus* has proved efficient composting earthworms in tropical or sub-tropical conditions [7,11]. The method of vermicomposting involving a combination of local epigeic and anecic species of earthworms (*Perionyx excavatus* and *Lampito mauritii*) is called Vermitech [12]. The compost prepared through the application of earthworms is called vermicompost and the technology of using local species of earthworms for culture or composting has been called Vermitech [11]. Vermicompost is usually a finely divided peat-like material with excellent structure, porosity, aeration, drainage and moisture holding capacity [13, 14]. The nutrient content of vermicompost greatly depends on the input material. It usually contains higher levels of most of the mineral elements, which are in available forms than the parent material [15]. Vermicompost improves the physical, chemical and biological properties of soil [7]. There is a good evidence that vermicompost promotes growth of plants [16] and it has been found to have a favourable influence on all yield parameters of crops like wheat, paddy and sugarcane [12].

How to Use Vermicompost?

- Vermicompost can be used for all crops: agricultural, horticultural, ornamental and vegetables at any stage of the crop.
- For general field crops: Around 2–3 t ha^{-1} vermicompost is used by mixing with seed at the time of sowing or by row application when the seedlings are 12–15 cm in height. Normal irrigation is followed.
- For fruit trees: The amount of vermicompost ranges from 5 to 10 kg per tree depending on the age of the plant. For efficient application, a ring (15–18 cm deep) is made around the plant. A thin layer of dry cow dung and bone meal is spread along with 2–5 kg of vermicompost and water is sprayed on the surface after covering with soil.
- For vegetables: For raising seedlings to be transplanted, vermicompost at 1 t ha^{-1} is applied in the nursery bed. This results in healthy and vigorous seedlings. But for transplants, vermicompost at the rate of 400–500 g per plant is applied initially at the time of planting and 45 days after planting (before irrigation).
- For flowers: Vermicompost is applied at 750–1000 kg ha^{-1}.
- For vegetable and flower crops vermicompost is applied around the base of the plant. It is then covered with soil and watered regularly.

2.4. Wastes utilized in vermitechnology

Earthworms can be fed easily on different forms of non toxic organic waste foods produced in the nature. The common wastes produced by the forests, agriculture and urban areas are mainly abundant organic wastes. They include kitchen wastes, vegetable market wastes, sewage sludge, garden wastes, animal excreta, weeds coir wastes, leaf litter, paper and pulp wastes, feed and fodder wastes and aquatic biomass [17].

The disposal of these organic wastes in an unscientific manner causes many problems such as fly breeding, pig menace, transmission of pathogens, soil and air pollution, surface and ground water pollution, irritating odour [18]. The lack of awareness, co-operation among people and even shortage of funds by state and central Governments are the main causes of improper disposal of solid waste management especially in urban areas [19].

The biologically degradable and decomposable organic wastes can be commonly used as composting materials in vermitechnology are

Animal dung: Cattle, sheep, horse, goat, poultry wastes etc.
Agricultural wastes: Agri-wastes obtained during and after harvesting and threshing.
Forestry wastes: Wood shavings, peels, saw dust and pulp etc.
City garbage and leaf litter: Kitchen wastes and leaf litter of street plants and residential areas.
Paper and cotton industry wastes: Wastes generated from paper and cotton cloth industry.

Biogas slurry: After the recovery of biogas, slurry is used.
Industrial wastes: Wastes from food processing industries like dal mill, rice mill etc.

2.5. Earthworms used in vermitechnology

Only few epigeic and anecic earthworm species are widely used in vermitechnology throughout the world for the production of vermicompost and worm biomass. In India, only three species are being extensively used for verniculture and vermicomposting practices such as

1. *Eudrilus eugeniae* – African Night Crawler
2. *Eiseniafetida* - European Night Crawler
3. *Perionyxexcavatus,* - Oriental worm

Several other species ca n also be used, but they have to be tested before their use with different aspects like inbuilt ada stability to climatic conditions, feeding and breeding rates, life longevity, distribution range and availability etc.

2.6. Vermiwash

Vermiwash is a liquid that is collected after the passage of water through a column of worm action and is very useful as a foliar spray. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules. These are transported to the leaf, shoots and other parts of the plants in the natural ecosystem. Vermiwash, if collected properly, is a clear and transparent, pale yellow coloured fluid [20]. Vermiwash, a foliar spray, is a liquid fertilizer collected after the passage of water through a column of worm activation. It is a collection of excretory and secretory products of earthworms, along with major micronutrients of the soil and soil organic molecules that are useful for plants [20]. Vermiwash seems to possess an inherent property of acting not only as a fertilizer but also as a mild biocide [21]. It is found to contain a number of enzymes viz. proteases, amylases, urease and phosphatase [22], soluble plant nutrients, organic acids and mucus of earthworms and microbes.

2.7. Role of earthworms in Organic Waste Management

Earthworms not only act in the soil as aerator, grinders, crushers, chemical degrader and biological stimulators. They also secrete many more enzymes namely proteases, lipases, amylases, celluloses and chitinases, which brings about rapid biochemical conversion of the cellulosic and proteinaceous materials of various organic wastes and in fast recycling of available plant materials. Earthworms create aerobic conditions in the waste materials inhibiting the activity of anaerobic microorganisms, which can cause foul smell. Further, earthworms release coelomic fluid in the decaying organic materials, which have antibacterial properties that kills pathogens in the produced vermicompost [23].

In recent years, disposal of organic wastes from various sources like domestic, agriculture and industrial has caused serious environmental hazards and economic problems. Burning of organic wastes contributes tremendously to environmental pollution thus, leading to polluted air, water and land. This process also releases large amounts of carbon dioxide in the atmosphere, a main contributor to global warming together with dust particles. Burning also destroys the soil organic matter content, kills the microbial population and affects the physical properties of the soil [24]. It has been demonstrated that earthworms can process household garbage, city refuse, sewage sludge and waste from paper, wood and food industries. In tropical and subtropical conditions *Eudrilus eugeniae* and *Perionyx excavatus* are the best vermicomposting earthworms for organic solid waste management [7]. The use of earthworms in composting process decreases the time of stabilisation of the waste and produces an efficient bio-product, *i.e.,* vermicompost. Organic farming system is gaining increased attention for its emphasis on food quality and soil health. Vermicompost and vermiculture associated with other biological inputs have been actually used to grow vegetables and other crops successfully and have been found to be economical and productive [12,25,26]. In this regard, recycling of organic waste is feasible to produce useful organic manure for agricultural application. Compost is becoming an important aspect in the quest to increase productivity of food in an environmentally friendly way.

Compost is becoming an important aspect in the quest to increase productivity of food in an environmentally friendly way. Vermicomposting offers a solution to tonnes of organic agro-wastes that are being burned by farmers and to recycle and reuse these refuse to promote our agricultural development in more efficient, economical and environmentally friendly manner. Both the sugar and rice industries burn their wastes thereby, contributing tremendously to environmental pollution thus, leading to polluted air, water and land. This process also releases large amounts of carbon dioxide in the atmosphere, a main contributor to global warming together with dust particles. Burning also destroys the soil organic matter content, kills the microbial population and affects the physical properties of the soil.

Therefore organic farming helps to provide many advantages such as; eliminate the use of chemicals in the form of fertilizers/pesticides, recycle and regenerates waste into wealth; improve soil, plant, animal and human health; and creating an eco-friendly, sustainable and economical bio-system models.

III. Conclusion

Earthworms can consume large quantity of organic wastes rapidly and process them through gizzard and microorganisms so as to excrete vermicasts. Thus, treatment of any non toxic organic wastes by Vermitechnology is not only reduces pollution, eliminating pathogenic diseases but also produces a valuable product immense to agriculture; hence, vermitechnology is called 'wealth from wastes'. Environmental Hazards are compounded by accumulation of organic waste from different sources like domestic, agricultural and industrial wastes that can be recycled by improvised and simple technologies. Vermicompost could be effectively used for the cultivation of many crops and vegetables, which could be a step towards sustainable organic farming. All vermiculture technologies – vermicomposting (for solid waste management), vermifiltration (for wastewater treatment), vermiremediation (for land and soil decontamination) and vermiagro production (use of vermicompost for farm production) can be used as most economical and sustainable alternatives to some of the 'environmentally unfriendly' civil engineering methods to achieve those objectives of development while also significantly reducing waste and pollution and the emission of green house gases (GHG). Earthworms are truly justifying the beliefs and fulfilling the dreams of Sir Charles Darwin who called them as 'unheralded soldiers' of mankind and 'friends of farmers' and said that "there may not be any other creature in world that has played so important a role in the history of life on earth". Such technologies in organic waste management would lead to zero waste techno farms without the organic waste being wasted and burned rather then would result in recycling and reutilization of precious organic waste bringing about bioconservation and biovitalization of natural resources.

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