

VERMICAST: PRODUCTION AND PRACTICES FOR SUSTAINABLE ENVIRONMENT

Abstract

The vermicompost is effective and eco-friendly natural manure for the sustainable agriculture, which is also an ideal substitute for the synthetic fertilizers and a good feed for the beneficial microorganism that assists the plant growth. It accelerates the decomposition process of plant litter and debris so that plants can easily incorporate them for their growth. This process also reduces the volume of organic wastes into natural manure thus it can be considered as an effective organic waste management. This chapter reviews the organic waste management through vermicomposting for sustainable environment.

Keywords: vermicomposting and sustainable environment.

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I. INTRODUCTION

Human society depends on agriculture for its basic needs such as food, clothing and shelter. The continuous practice of intensive farming practices greatly reduces the nutrient and fertility of the soil day by day and greatly reduces the yield of crop. Currently, recycling and management of organic wastes have become an important to ensure the nutrient requirements of plants and sustainable soil health by improving the physico-chemical properties of the soil and maintaining the diversity of micro and macrophages. Adaptive mechanisms of macrophages such as various habitats, food sites and earthworms are important for studies on their role in organic waste management. Apart from this, the continuous inflation of fertilizers and the energy requirements for agricultural practices and the disposal of natural agricultural wastes are of concern to the farmers and it is very difficult to remove the organic matter produced by the distillery and tea factories so that the organic matter can maintain the sustainable environment by making earthworm composts. Earthworm composting is not only a technology for composting, but also a solution to some extent of pollution and helps to preserve the diversity of earthworms (Moorthiet *al.*, 2019). In view of the above facts, the chapter aims to inform the management of pollution by vermicompost for sustainable environment.

II. ORGANIC WASTE MANAGEMENT

In India, the organic wastes productions are estimated annually to be more or less 7.1, 3.0 and 7.6 million tons of nitrate, phosphate and potash respectively. Using the above source, about 0.7 Tg Y⁻¹ can be used to make good quality compost and increase the plant nutrients required for plants such as nitrogen, phosphorus and potassium. Organic waste can be disposed of by a number of methods, including landfill, incineration, pyrolysis, recycling, biogas and composting. Earthworm manure is one of the most suitable in terms of environmental protection from the above disposal methods in organic waste management (Loreset *al.*, 2006).

The vermicomposting is the most extensively used technique for manage biodegradable waste. Furthermore, this technique reduces the number of wastes to be disposed of and also converts them into useful material, for agricultural applications. Although composting is a natural process and has many benefits, vermicompost is considered to be superior in its unique benefits. Vermiculture is a scientific process in which selected species of earthworms are raised in artificial and controlled environments to produce earthworm compost. Vermicast is mainly made with humus rich in worm droppings. Earthworms are fed with cow dung and farm manure to make earthworm compost. Organic municipal waste, non-toxic and liquid industrial waste, and even household organic waste can be converted into vermicompost in a similar manner. Earthworms not only turn garbage into valuable compost, but also help keep the environment healthy. Earthworm rearing, population growth and composting can be done easily by trained farmers (Moorthiet *al.*, 2018).

The vermicompost is produced as a result of the combined action of natural stabilization and bio-oxidation of organic wastes by microorganisms along with enzymatic conditioning of the digestive system of the earthworms. The nutritional values of the compost production by the microbes alone are limited to some extent, as in the microbial degradation mechanical stirring, facilitating aeration, mechanical fragmentation of the substrates etc., are

lacking. However, the above setbacks are set right when the natural degradation of organic wastes by microbes is complemented by earthworms. Hence, earthworms are crucial drivers for the compost making process. Earthworms also act as a natural blender and transform its physical and chemical structure by slowly reducing the carbon and nitrogen ratio and elevate the surface area for microorganisms to react and further microbial decomposition. The vermicomposting process is a mesophilic process and operating conditions such as moisture content, pH, temperature and electrical conductivity ranges must be maintained (Dominguez *et al.*, 1997; Manyuchi and Phiri, 2014).

III. PHASES OF VERMICOMPOSTING

- The earthworms process the organic waste and converted the physical structure and the microbial decomposition of the compost at an active phase (Lores *et al.*, 2006)
- A maturation phase manifest by the displacement of the earthworms towards fresher layers of undigested waste, where the microbes take over process of decomposition of the waste.

In the process of vermicomposting, there is no fixed duration for active phase and it would depend upon various factors such as the species employed for the vermicomposting process, population density of the earthworms, their ability to ingest the waste etc. (Cristina *et al.*, 2008). Generally, the epigeic earthworms were ideal to employ in organic wastes management. The substrate for the production of the vermicompost needs to be pre-treated before it is introduced into the earthworm aggregate. The pre-treatment is intended to eliminate the toxic substances, which may harm the earthworms and lead to mortality. Nair *et al.* (2006) also suggested that the organic residues require pre-treatment before subjecting to vermicomposting process as they may also contain toxic substances which are toxic for earthworms (Moorthi *et al.*, 2017b). Vermicompost, a by-product of earthworm-mediated organic waste re-cycling, is rich in plant nutrients and growth-promoting substances and it is considered an inseparable component of sustainable farming (Choudhary *et al.*, 2001; Reddy and Ohkura, 2004). The several environmental factors like moisture, pH, temperature and stocking rate of earthworm, influences the degree of success of vermicomposting. Worm casts, when compared to worm un-worked soil or organic wastes reveal remarkable microbial and enzymatic activities and an enhanced ratio of macronutrients such as nitrogen, phosphorous, potassium and micronutrients like zinc, iron, magnesium, copper, etc. (Parthasarathi and Ranganathan, 1999).

The organic fertilizer enhances crop growth and yield, either directly by supplying nutrients or indirectly by modifying the soil properties, thereby improving the root environment. In addition to this, crop production based on the use of organic manures rather than chemical fertilizers is assumed to be a more sustainable sort of agriculture. Therefore, in recent years the application of organic fertilizer has increased great interest from researchers for enhance the sustainable environment (Mahaly *et al.*, 2017b).

IV. PREPARATION OF VERMICULTURE (EARTHWORM CULTURE)

A concrete ring with 13cm height and 25 cm width and 72 cm (round) length is selected. The bottom of the concrete ring was made to slope to remove the excess water. A small sump is needed to collect the drain water. A three-layered vermibed is prepared as

described under the first layer is made up of dried leaves and small twigs over the inside of the concrete ring; the second layer consisted of clay soil to the height of 4-6cm from the first layer; the third layer is the farmyard manure to a height of 7-9cm from the second layer. Water is sprayed at definite intervals in order to maintain 70% moisture of the vermibed. Earthworms are introduced in this vermibed after 2-3 days. These earthworms are treated as stock species (Moorthiet *al.*, 2011).

V. PREPARATION OF VERMICOMPOSTING

Rectangular wooden vessels 80 cm high, 40 cm long and 25 cm wide were taken with adequate holes to ensure better ventilation. The first layer was made of straw and small stones. The second layer is made of clay or clay. The third layer contains a lot of microorganisms so the cow dung is sprayed with water as required. The fourth layer was placed decomposed organic waste. About 25 young glossy earthworms weighing 200-250 mg were then placed in the worms. The worms were placed in small branches at the bottom of the tank and red soil up to 10 cm above it was designed to make it feel like it was at home. The humidity of the containers was maintained at 65-70% by spraying water during the study period (Moorthiet *al.*, 2018a). All the tanks were stored in dark place at room temperature. The earthworms came to the surface and took the food and spent the rest of the time producing the compost under the soil (Moorthiet *al.*, 2016).

VI. VERMICAST

Organic manure (earthworm) can be removed from the above vermicompost and the settled worms below can be carefully collected for use in the next batch of vermicompost. The vermicompost is collected and piled on a stretched paper sheet for 1 to 5 hours to reduce the moisture that the vermicast can contain (Moorthiet *al.*, 2018a).

VII. STORING AND PACKING OF VERMICOMPOST

Vermicast is harvested and stored in a dark and cool place. Humidity must be at least 40%. It kept away from direct sunlight to protect against moisture and nutrient value exhaustion. Harvested manure is kept in its original condition in a ventilated place without being placed in sacks or bags. Sprinkled water on time to maintain desirable moisture and microbial reliability on hot days, plastic sheeting is used to protect the moisture from evaporating the earthworm manure. If the humidity is maintained at 40%, the vermicompost can be stored for a year without loss of its nature (Moorthiet *al.*, 2016). Packing can be done when needed or at the time of sale. But it is not good to keep the fertilizer in airtight bags for a long time as it will reduce the quality of the fertilizer.

VIII. SELLING THE WORMS

An earthworm sells for minimum cost by contacting some farmers. To make more profit, you can decide to sell as an independent wholesaler or retailer or sell to fish supply stores. Earthworms can be sold by mail or by advertising in one or more national newspapers to fishing enthusiasts and nature gardeners. Sell worm feed to stores. High school and college biology classes use it to extract worms, sell new vermicompost to manufacturers, sell to research students, and sell to women's self-help groups.

IX. MARKETING OF ORGANIC FERTILIZER

- The vermicompost production marketing has worthy sales potential in a wide variety of agriculture, horticulture etc.
- Direct sales to end users, including farmers and subdivisions in nearby areas.
- Wholesale for organic fertilizer manufacturers and distributors who need high profit earthworm compost.

X. MAINTENANCE OF VERMICOMPOSTING

- Humidity in the duct should not exceed 40-50%. Bed water stagnation caused the changes of pH of the medium. These inhibit the regular functioning of the worms, leads to loss of weight and depletion of the worm population.
- The temperature of the bed should be in the range of 20-30 degrees centigrade. Care to be needed to avoid worm injured during handling.
- Protect from ants, small animals and rain water. Grow earthworms in shady places and earthworm bed should be protected from predators.

XI. ADVANTAGES OF VERMICOMPOST

- Earthworm manure is rich in all essential plant nutrients, thus giving the best outcome on plant growth such as promoting the growth of new leaves and shoots.
- Earthworm manure is odourless and very easy to handle and store.
- Manure improves soil texture, best aeration and adequate water resistance.
- Earthworm manure has numerous beneficial microorganisms that stabilize nitrogen and phosphorus in soil.
- Earthworm manure may increase the population in the soil by the cocoons and the population which neutralizes the acidity or alkalinity of the soil.
- Earthworm manure is free from pathogens, toxins and weed seeds.
- Earthworm compost reduces the impact of pests and diseases.
- It contains valuable vitamins, enzymes and hormones like auxins and gibberellins.
- The nutrients available in earthworm manure (generally) are organic carbon (9.5 - 17.98%), nitrogen (0.5 - 1.50%), phosphorus (0.1 - 0.30%), potassium (0.15 - 0.56%), sodium (0.30%), calcium and Magnesium (22.67 to 47.60 meq / 100g), copper (2 - 9.50 mg kg⁻¹), iron (2 - 9.30 mg kg⁻¹), zinc (5.70 - 11.50 mg kg⁻¹) and sulfur (128 - 548 mg kg⁻¹).
- Worm-products can be used as bio-fertilizers, while earthworms can also be used for other technologies such as vermicompost and worm-filtration and earthworm repellent.

XII. PREVENTIVE MEASURES IN VERMICOMPOST PRODUCTION

- The base of the unit should be compact and firm to prevent earthworms from escaping from the container into the ground.
- 15-20 days old cow dung should be used to avoid overheating.
- Organic waste should be free of plastics, chemicals, pesticides and metals.
- Ventilation should be maintained for proper growth and reproduction of earthworms.

- Optimal humidity (30-40%) should be maintained.
- 18-25°C temperature should be maintained for proper decomposition.

XIII. FACTORS AFFECTING COMPOSTING PROCESS

Fertilization is a biochemical process and is affected by basic environmental conditions. Many favourable conditions are required for compost preparation. Some important factors affecting the composting process are briefly reviewed (Moorthiet *al.*, 2018).

- 1. Moisture:** Optimal moisture is an essential factor when making compost. The initial humidity can be 45 to 70% and 50 to 60% (Parthasarathi and Ranganathan, 1999). Excess moisture creates anaerobic conditions because water displaces air from the space between the particles. Therefore, high humidity should be avoided, while low humidity may adversely affect microbial function.
- 2. Aeration:** Ventilation can be effective in reducing excess moisture in composting materials. Adequate oxygen must be provided to the organism for a rapid composting process. The supply of oxygen can be increased by blowing air into compost, by supplying airflows to the bottom of the composting mass, or by turning or constantly mixing the compost piles. Turning the object is the most common method of ventilation. Turning is often referred to as the primary mechanism of ventilation and temperature control during window compaction. Turning is generally believed to be a factor that eliminates the compost rate, time required to reach full maturity and phytotoxicity and compost quality. Higher oxidation rate increases ammonia evaporation and nitrogen loss.
- 3. Temperature:** Proper temperature control is an important factor in the aerobic composting process. Temperatures above 45°C are required to destroy pathogenic organisms and weed seeds. The predominance of information on the impact of temperature on compost preparation indicates that the optimum decomposition takes place at 55 to 60°C. Decomposition in the thermophilic temperature range (60-70°C) continues very rapidly. Maximum ammonification occurred during composting at temperatures between 60°C and 70°C, and in this temperature range, the nitrification rate was low. But a temperature of about 60°C is very satisfactory for successful composting. Temperatures above 65°C kill many types of microorganisms and release decomposition rates (Bhadauria *et al.*, 2000).
- 4. pH:** pH of the composting material impacts the kind of organisms which involved in the vermicomposting. The best possible pH range for most bacteria is between 6 and 7.5 whereas for fungi, it can be in between 5.5 and 8.0. Furthermore, organic matter with a wide range of pH that is 3 to 10 can be composted and recommended that optimum levels between 6 and 8 and between 4.0 and 7.0 for end product. High initial pH of the composting is a major factor leading to nitrogen loss by ammonia volatilization. At a low level pH the balance between ammonium ion and dissolved ammonia is shifted towards the ammonium ion, thus reducing ammonia volatilization during the thermophilic stage of composting.

- 5. Carbon/Nitrogen ratio (C/N Ratio):** The ratio of carbon to nitrogen affects the speed and efficiency of compost production. In other words, the rate at which organic matter decomposes during composting depends mainly on the carbon/nitrogen ratio of the material. During composting, more carbon is needed than nitrogen because microorganisms use carbon as a source of energy and nitrogen to build cell structures. But if the carbon is high, the decay decreases. When the availability of carbon is less than that required converting the available nitrogen to protein, the microbes use up most of the available carbon, and nitrogen loss can occur as the ammonia evaporates (Abbiramy *et al.*, 2018).

The C/N ratio was between 26 and 40, and nitrogen loss was greatly reduced. At low C/N ratios, microorganisms get more nitrogen than they need to use carbon, so significant amounts of ammonia and nitrogen volatile forms are lost. When nitrogen is low compared to carbon, mineral nitrogen is inactive in microbiology during the decomposition of carbonaceous materials. When some microbes die, microbial nitrogen is used by other microbes (Senthilkumaret *al.*, 2016). The optimum C/N ratio is 20 to 25 parts carbon to 1-part nitrogen.

However, studies indicate that the C/N ratio is in the optimal range of 50: 1 and that better results are acquired with the higher proportions as proved by successful composting of leaves, sugarcane, sawdust, and cotton waste.

The waste may require severe nitrogen deficiency, low amounts of urea or other nitrogen sources. Nitrogen loss during composting can be reduced by using compounds with a higher C/N ratio, which improves mobility (Moorthiet *al.*, 2017).

- 6. Microorganisms:** Fertilization is a dynamic process in which physical and chemical changes are caused by the rapid continuum of mixed microbial populations. Bio-waste products contain a wide variety of bacteria, fungi, molds, etc. Microbial activity has a very significant effect on compost preparation. It appears that more types of bacteria are involved in aerobic decomposition than anaerobic decomposition. According to Satchell (1971) the nutrient availability are the greatest influence on determining the earthworm species that make up the population at any given time.
- 7. Perspectives:** The data on the estimation of species abundance and species richness are negligible. The abundance of Megascolecidae and Eudrilidae might be due to the highest moisture content.

Furthermore, the soil has rich in organic matter, high to medium soil porosity with slightly acidic to neutral pH and these are the ideal environment for the proliferation of earthworm species. *Lampitomauriti*, *Perionyxexcavatus* and *Eudriluseugeniae* are the most abundant during July to October and active species in different habitats. Further research is essential to learn and extend the method to develop these earthworm species for the enhancement of soil to conserve the soil fertility for the sustained agricultural development. At the same time the vermicompost is ideal organic manure for better growth and yield of many plants. Studies suggested that treatments of humic acids, plant growth promoting bacteria and vermicompost can be used for a sustainable agriculture discouraging the use of chemical fertilizers. In short, the conversion of vermicompost

provides a sound solution for the disposal of organic wastes, to rule out the problem of pollution. The disposal of organic wastes as manures help in meeting the nutrient requirement of crops as well as sustaining soil health by maintaining soil organic matter status. Thus, it proves that the vermicomposting techniques are economically viable, socially acceptable and environmentally sensible one to the industrialists and farmers.

REFERENCES

- [1] Abbiramy, K. S., Ronald Ross, P., Moorthi, M. and Chitrapriya, K. (2018). EC50 of PK fertilizers on *Eisenia fetida* (Savigny) by Avoidance, Behavioral Test, *Res J. Chem. Environ. Sci.*, 6 (4) August 2018: 48-53 online ISSN 2321-1040.
- [2] Bhadauria T., Ramakrishnan P.S. and Srivastava K.N. (2000). Diversity and distribution of endemic and exotic earthworms in natural and regenerating ecosystems in the central Himalayas, India. *Soil Biol. Biochem.*, 32(14), 2045–2054.
- [3] Choudhari P.S., Pal, T.K., Bhattacharjee, G. and Dey, S.K. (2001). Nutrient changes during vermicomposting by *Perionyx excavates* on the specific used, *Trapabispinosa*. *Philipp. J. Sci.* 130, 127 – 133.
- [4] Cristina, L., Maria, G.B. and Jorge, D. (2008). Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere*, 72, 1013 – 1019.
- [5] Dominguez, J., Edwards, C.A. and Subler S. (1997). A comparison of composting and vermicomposting. *BioCycle*, 4: 57 – 59.
- [6] Lores, M., Comez-Brandon, M., Perez, D. and Dominguez, J. (2006). Using FAME profiles for the characterization of animal wastes and vermicomposts. *Soil Biol. Biochem.* 38: 2993 - 2996.
- [7] Manyuchi, M.M. and Phiri A. (2014). Vermicomposting in solid waste management: A review, *International Journal of Sci. Eng. Technol.* 2 (12), 1234 – 1242.
- [8] Moorthi, M., Senthilkumar, A. and Srimathi, R. (2019). Assessment of Cocoon Production of *Eudriluseugeniae* through Bioconversion of Distillery Solid Waste with Elephant Dung. *International Journal of Zoology and Animal Biology*, (11) 2-7p : 000192. ISSN: 2639-216X.
- [9] Moorthi, M., Nagarajan, K., Senthilkumar, A., Thangaraj, A. and Abbiramy, K.S. (2018). Diversity of earthworm species from various habitats of Erode District, Tamil Nadu. *Proceedings*.
- [10] Moorthi, M., Abbiramy, K.S., Senthilkumar, A., Chitrapriya, B., Kaliyaperumal, A. and Nagarajan, K. (2018a). Vermicomposting of distillery sludge waste with tea leaf residues, *Sustainable Environment Research*, 28, 223 -227.
- [11] Moorthi, M., Nagarajan, K. and Senthilkumar, A. (2017). Heavy metal accumulation by earthworm *Eudriluseugeniae* in distillery solid waste and other carbonaceous waste using vermicomposting. *J. Earth Environ. Sci.* 7, 1-4.
- [12] Moorthi, M., Abbiramy, K.S. and Senthilkumar, A. and Karupannan Nagarajan (2017b) Vermitechnology – An Eco-Biological Tool for Sustainable Environment, *Biotechnology for Sustainability, Achievements, Challenges and Perspectives Biotech Sustainability* (2017), P41-50 ISBN: 978-967-14475-3-6; eISBN: 978-967-14475-2-9.
- [13] Moorthi, M., Nagarajan, K. and Senthilkumar A. (2016). Vermitechnology of organic solid waste with using earthworm *Eudriluseugeniae*. *J. Zool. Stud.*, 3, 48 - 51.
- [14] Moorthi M. and Nagarajan K. (2011). Biomanagement of distillery solid waste using earthworm *Eudriluseugeniae*. *J. Ind. Pollut. Control*, 27, 169 - 172.
- [15] Nair, J., Sekiozoic, V. and Anda, M. (2006). Effect of pre-composting on vermicomposting of kitchen waste. *Biores. Technol.*, 97, 2091 – 2095.
- [16] Parthasarathi, K. and Ranganathan, L.S. (1999). Longevity of microbial and enzyme activity and their influence on NPK content in press mud vermicasts, *Eur. J. Soil. Biol.*, 35 (3), 107-113.
- [17] Reddy, V.M. and Ohkura, K. (2004). Vermicomposting of rice straw and its effects on Sorghum growth. *Tropical Ecol.*, 45, 327 – 331.
- [18] Senthilkumar, A., Nagarajan, K. and Moorthi, M. (2016). Microbial Reduction of Chromium (VI) in Tannery Waste Contaminated Soil through Optimum Concentrations of Biomass, Molasses and Mineral Medium using Miniature Reactor. *International Journal of Scientific & Engineering Research*, 7 (3): 722 – 728.
- [19] Satchell, J.E. (1971). Earthworms. In: Philipson J (ed) *Methods of study in quantitative soil ecology: population. Production and energy flow*. Blackwell Scientific Publications, Oxford, 107–127.