Chapter 15
Role of Vermicomposting in Agricultural Waste Management

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Abstract Agricultural wastes including food processing wastes are the by-products of various food industries that have not been recycled or utilized for other purposes. These agri-horticultural wastes constitute a big problem in municipal landfills due to their high rate of biodegradability. In other words, they are actually the unutilized raw materials whose industrial applications are less than their cost of collection and recovery; and therefore they are generally considered as wastes. The major agricultural sources are livestock, crop residues, tree wastes, aquatic weeds, agro-industrial byproducts, marine wastes and tank silt. The advancement of agricultural biotechnology has led to the development of high yielding variety crops and their subsequent crop residues such as straw, leaves twigs, stubbles along with huge amounts of grasses and weeds. During vermicomposting, stabilization of organic waste occurs through the joint activity of earthworms and aerobic micro-organisms. Vermicomposting is ecofriendly and an economic technique for management of agricultural waste. The earthworm *Eisenia foetida* is one of the most common species used in vermicomposting. The temperature of the earthworm feed should be in the range of 20–35 °C along with relative humidity between 60–80%. Commonly known as farmer's friends, the earthworms improves the fertility of the soil by decomposition of organic matter. In this process, the earthworms leave behind their castings that are exceptionally a rich source of bio-fertilizer. Physico-chemical analysis had shown that vermicomposting decreases total organic carbon (TOC) and carbon-nitrogen (C/N) ratio but increases nitrogen-phosphorus-potassium (NPK) content when compared to compost and other agricultural wastes. The other areas of its application are for crop improvement through pathogen destruction (biocon-

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trol), improving the water holding capacity of soil and production of plant growth regulators. All these factors will ultimately lead to improved crop growth and yield, and better soil physical, chemical and biological properties.

Keywords Earthworms · Vermicompost · Waste-management · Agricultural waste · Organic manure

15.1 Introduction

In a study in 1994, it was estimated nearly 700 million tonnes organic waste is generated annually in cities and rural areas of India, which is either burned or land filled (Bhiday 1994). Food processing industries produces large volumes of wastes, comprising of both solids and liquid. These food wastes pose though rich in nutrients and biomass poses threat to the environment thereby increasing pollution problems. Many studies have shown that these organic wastes have potential to be converted into useful products or even as raw material for other industries. They can also be used as animal feed after little biological treatment.

The problem in environment management usually arises due to the farmers that bring their agriculture produce to the market without grading and cleaning it. Thus the organic waste in the market area increases, that in turn pressurizes and disturbs the ecosystem of agricultural-waste management. Most of the uncollected waste starts decaying at the market site. This in turn creates sanitation problems and hygiene hazards to the common people (Mane and Rasker 2012). Thus it can be observed that inadequate management of organic wastes can lead to the disease outbreak and also have harmful effects on environment.

In the view of above, vermicomposting offers an attractive alternative in environment management. It also generates viable animal feed protein in the form of worm biomass, while alleviating the negative effects of poor organic waste management. Vermicompost develops due to the biological activity of earthworms that consumes mainly organic materials, such as food preparation residuals and leftovers, scrap paper, animal manure, crop residues, including organic by-products from industries, and yard trimmings. Thus wastes are converted into a valuable biofertilizers that can be used in soil amendment for plants and crops.

The other advantages of vermicomposts are it boosts the soil nutrients, increases the availability of nutrients to plants, improves soil structure and drainage, increases the plant growth and suppresses plant disease and insect pest attacks (biocontrol). Thus vermicompost is one of the efficient means to mitigate environmental-pollution problems and for its management (Waleed 2016).

15.2 Vermicomposting

There is a vast microflora that includes both micro- and macro-organisms that have the ability to decompose organic wastes into valuable resources containing both plant nutrients and organic matter, which plays a vital role in maintaining soil productivity. Vermicomposting mainly involves the biodegradation activity of earthworms to maintain nutrient flow from one system to another. It is observed that the earthworm population decreases with soil degradation and are used as a sensitive indicator of soil degradation.

Charles Darwin described earthworms as the 'unheralded soldiers of mankind', and Aristotle called them as the 'intestine of earth', as they could digest a wide variety of organic materials (Darwin and Seward 1903; Martin 1976). Earthworms participate in cellulose degradation, soil formation and humus accumulation. Due to the biological activity of earthworms, the physical, chemical and biological properties of soil are adversely affected. Earthworms feed on organic wastes and are unique as they consume only a small portion from these wastes for their growth and excrete a major proportion of wastes in a partially-digested form (Jambhekar 1992). This is because the intestine of earthworms contain an array of micro-organisms, hydrolytic enzymes and hormones which helps in rapid decomposition of partially-digested material thereby transforming the complex organic matter into vermi-compost in a relatively smaller duration of 1–2 months (Nagavallemma et al. 2004) as compared to traditional composting process which takes the longer duration of nearly 5 months (Sánchez-Monedero et al. 2001).

The mechanism of action of digestion and formation of vermicompost by earthworms occurs in many steps. The organic matter passes through the gizzard of the earthworm where it is grounded into fine powder. Thereafter the hydrolytic enzymes such as cellulase, amylase, lipase, protease, urease and chitinase (Munnoli et al. 2010), micro-organisms and other fermenting substances further helps in their breakdown within the gut, that finally passes out in the form of "casts". These are finally known as the "vermicomposts" (Dominguez and Edwards 2004).

Such earthworms are known as "epigeic" earthworms. Their characteristic features are efficient bio-degradation and nutrient release, tolerant to disturbances, and helps in early decomposition of litter. Epigeic earthworms include *Lumbricus rubellus, Eisenia foetida, Eiseniella tetraedra, Lumbricus castaneus, L. festivus, Bimastus minusculus, B. eiseni, Dendrobaena veneta, Dendrodrilus rubidus,* and *D. octaedra.* As a result of earthworm's activity, the soil loosens and becomes porous. The porosity increases aeration, water absorption, drainage and easy root penetration. The soil aggregates thus formed by earthworms and associated microbes, helps in maintaining soil ecosystem. These aggregates are mineral granules bonded in a way to resist erosion and to avoid soil compaction both in wet and dry condition. Earthworms speed up soil reclamation and make them productive by restoring beneficial microflora (Nakamura 1996). Thus degraded unproductive soils and land degraded by mining could be engineered physically, chemically and biologically and made productive by earthworms. Hence earthworms are termed as ecosystem engineers (Munnoli et al. 2010).

Vermicomposting does not lead to rise in temperature and so can be aptly defined as a non-thermophilic, bio-oxidative process that produces highly fertile compost with the help of biological activity of earthworms and other associated microbes present in the soil. The final product thus obtained is called vermicompost. The bio-physico-chemical properties of vermicomposts include finely divided, peat like, porous, good aeration and drainage, high water holding capacity, with greater microbial activity and buffering capacity. During vermicomposting, many plant growth-regulating hormones and enzymes are produced that enhances soil biodiversity by promoting the beneficial microbes which in turn enhances plant growth. They also help to control plant pathogens, nematodes and other pests, thereby enhancing plant health and minimize the yield loss. Thus vermi-compost offers an attractive alternate to promote sustainable agriculture and safe management of agricultural, industrial, domestic and hospital wastes (Pathma and Sakthive 2012).

The various types of raw materials and earthworm species used in vermicomposting are presented in Table 15.1.

15.2.1 Precautions During Vermicomposting

Various research studies have shown that only the African and not the Indian species of earthworms, *Eisenia foetida* and *Eudrilus eugenae* are ideal for the preparation of vermicompost. The other consideration is that select only plant-based materials such as grass, leaves or vegetable peelings in preparing vermicompost. Materials of animal origin including bone, meat, eggshells, chicken droppings, etc. should be avoided for preparing vermicompost. *Gliricidia* loppings and tobacco leaves as earthworm feed are also not desirable for their rearing. Earthworms are susceptible to be attacked by birds, termites, ants and rats hence they should be protected from them; adequate moisture should also be maintained during their rearing because both stagnant water or lack of moisture are lethal for them. As the process gets completed, the vermicompost should be removed from the bed and replaced by fresh waste materials.

15.3 Management of Flower Waste by Vermicomposting

Management of flower wastes through vermicomposting is another extension to its application. In a recent study, the management of flower waste in the temples of Indore city, India was assessed. The waste from the temples are usually rich in organic matter and comprises of mainly vegetable material such as flowers, leaves, fruits, sugar, jaggery, grains, milk and milk products, and water. These wastes are normally biodegradable and are readily available for the growth of microbes. These

Table 15.1 Various types of Raw Materials and Earthworm Species Used in Vermicomposting

S. No.	Raw material	Earthworm species
1.	Agricultural residues	*Eudrilus eugeniae*
2.	Agriculture waste and sugar cane thrash	*Eudrilus eugeniae, Perionyx excavates*
3.	Board mill sludge	*Lumbricus terrestris*
4.	Canteen waste & vegetable waste	*Eisenia foetida*
5.	Cattle manure	*Eudrilus eugeniae*
6.	Deciduous forest waste, cow-dung	*Eisenia foetida*, *Perionyx excavatus* and *Dicogaster bolaui*
7.	Different mammalian animal waste	*Eisenia foetida*
8.	Domestic waste + cow-dung	*Perionyx excavates, Perionyx sansibaricus*
9.	Fly ash + cow dung	*Eisenia foetida*
10.	Gaur gum	*Eudrilus eugeniae*
11.	Grass clippings, cow dung	*Eisenia foetida,*
12.	Green waste	*Eisenia andrei*
13.	*Imperata cylindrica* grass	*Perionyx excavatus, Eisenia foetida*
14.	Municipal solid waste	*Eisenia foetida, Eudrilus eugeniae*
15.	Municipal, agricultural and mixed solid waste	*Eudrilus eugeniae*, Perionyx excavates
16.	Onion residue/waste	*Eisenia foetida, Eudrilus eugeniae*
17.	Organic matter, moistened peat moss, crushed leaves, dried yard waste	*Eisenia foetida*, *Lumbricus rubellis*
18.	Organic wastes	*Lumbricus rubellus, Eisenia jetida, Eisenia andrei, Dendrobdena rubida, Eudrilus eugeniae, Perionyx excavatus* and *Eiseniella tetraedra.*
19.	Paper mill sludge	*Lumbricus rubellus, Eisenia foetida*
20.	Pig manure, food wastes, leaf wastes, yard wastes, bark wastes, chicken manure	*Eisenia foetida*
21.	Potato peels	*Pheretima elongate*
22.	Press mud	*Pheretima elongate, Eudrilus eugeniae, Eisenia foetida, Megascolex megascolex, Perionyx ceylanensis, Drawida willsi*
23.	Bagasse, sugar cane trash	*Drawida willsi*
24.	Sago waste	*Lampito mauritii, Eisenia foetida*
25.	Sericulture waste	*Perionyx excavates*
26.	Sheep manure + cotton industrial waste	*Eisenia foetida*
27.	Shredded paper or newspaper, coir (coconut husk fiber)	*Perionyx excavatus*
28.	Source separated from human faeces	*Eisenia foetida*
29.	Sugar cane residues	*Pheretima elongate*
30.	Vegetable waste + floral waste	*Eudrilus eugeniae, Eisenia foetida, Perionyx excavates*
31.	Wooden or plastic	*Eisenia foetida, Eudrilus eugeniae, Perionyx excavates*

From Sobana et al. (2016)

wastes are either directly released in the water bodies or dumped at the available places of land as such without giving any further treatment. This creates severe environmental pollution and health hazards. So vermicomposting method was adopted to manage temple waste. The steps include the mixing of cow dung in temple waste-solids and are allowed to decompose for 45 days at 30 °C. After partial decomposition, *Eudrilus eugeniae* earth worm species are introduced into the waste. The process is subjected to optimization of parameters like pH of material, electrical conductivity, C/N ratio and temperature. The optimum parameters for vermicomposting of flower waste are temperature (25 °C), pH 8.0, Electric conductivity (200 microSiemens/cm). Vermicompost obtained by this method was rich in C/N ratio 12.3 after 45 day of vermicomposting. The cost production of vermicomposting of flower waste was worked out and its viability for the Indore city was also justified (Kohli and Hussain 2016).

15.4 Management of Bagasse by Vermicomposting

Agro-industrial wastes such as bagasse are pre-decomposed for 40 days, and subsequently vermicomposting is performed for 30 days through the introduction of *Eisenia foetida* at 26 °C temperature and 62–82% moisture content. The earthworm species decomposes the organic matter through their digestive enzymes and during this process leaves behind castings that function as a valuable fertilizer. Physico-chemical analysis revealed that there is a decrease in total carbon (TC), C/N ratio while increase in NPK content in vermicompost when compared to compost and initial agro-industrial waste (bagasse). The other advantages of vermicomposting are in crop improvement, pathogen destruction (biocontrol), improves water holding capacity of soil and production of plant growth regulators. All these factors lead to improved crop growth and yield, improved soil physical, chemical and biological properties (Jaybhaye and Bhalerao 2016).

15.5 Management of Banana Agro-Waste by Vermicomposting

The waste generated from banana is vast as it is a major crash crop in India. A study was conducted to investigate the vermicomposting potential of banana agro-waste (dried leaves and pseudo-stem biomass). The organic waste material was mixed with cow-dung using earthworm *Eudrilus eugeniae,* it was found that the optimal growth and reproduction was obtained in the ratio of 200 g banana waste and 800 g cow dung mixture. Favourable growth and reproduction was also observed in combination of 200 g banana waste and 600 g cow dung mixture. It was also observed that the earthworm could not survive in the treatments of 1000 g banana waste alone; mixture of 800 g banana waste and 200 g cow dung; and also in mixture of 600 g banana waste and 400 g cow dung. Thus the above research showed that higher amounts of banana waste in feed mixtures is injurious for the growth and reproduction of earthworms. Besides this, irrespective of proportion of banana waste and cow dung in the vermicomposting treatment mixture, a decrease in pH, organic carbon (OC), C/N ratio, and an increase in N, P and K was observed. Thus banana waste can be easily managed through vermicomposting if mixed with cow dung (CD) in suitable amounts (Kavitha et al. 2010).

15.6 Management of Agro-Industrial Waste Water Through Vermicomposting

There are several studies that reported the management of agro-industrial waste water through vermicomposting. A research showed that when highly polluted agro-industrial wastewater of a palm oil mill was treated using earthworms into vermicompost, the process significantly reduced the C/N ratio (0.69–79%), soluble chemical oxygen demand ranging from (20–88%) and volatile solids ranging from (0.7–53%). The palm oil mill effluent (POME), which is a waste water, was absorbed into amendments (soil or rice straw), and was used as feed-stocks for the earthworm *Eudrilus eugeniae*. During vermicomposting, there was a significant increase in pH, electrical conductivity and nutrient content. In this study, it was found that rice straw was a better amendment and absorbent as compared to soil, due to its higher nutrient content and greater reduction in soluble chemical oxygen demand (COD) and a lower C/N ratio. In addition, the growth of the earthworms was also reduced in all treatments. It was concluded that the treatment involving mixture in the ratio of 1 part rice straw and 3 parts palm oil mill effluent (w/v) produced the best quality vermicompost with high nutritional status (Lim et al. 2014).

In yet another study, the chemical characteristics of vermi-composts obtained from cattle manure (CM), orange peel (OP) and filter cake (FC) was evaluated. Three compost piles were set up in the sequence 2:1 OP and CM, 3:1 FC plus CM and CM. The piles were initially composted for 60 days and thereafter, earthworms were added to initiate the vermicomposting process. It was found that the pH and organic carbon contents were above the minimum recommended values for organic fertilizers but the C/N ratio was in the required range. However, the N content was low. So it was concluded that co-vermicomposting of filter cake and orange peel with cattle manure can be applied in sustainable agriculture (Pigatin et al. 2016).

15.7 Status of Vermicomposting of Agro-Waste

It is now well known that vermicomposting is the most promising bio-fertilizer which besides increasing the plant growth and productivity by nutrient supply, is economic and ecofriendly. As a result of degradation activity of earthworms, the mineralization of nutrients is enhanced, that increases crop productivity. Vermicompost produced from the farm wastes improves soil health and growth, enhances quality and crop yield and helps in pollution control. The technique can also be used to generate additional revenue (economic benefits) e.g. as for Baramati Agriculture Produce Marketing Committees (APMC). Nowadays, vermicomposting production units are being constructed to solve the problem of disposing the agro-wastes as no hazardous effluents are generated during the process such as no pesticide residues, weed seeds, heavy metals, and, termite or wax, plant root diseases, etc. Moreover, vermicompost can be used for all types of crops of agricultural, horticultural, ornamental and vegetables and at any stage. Practicing vermicompost for disposal of fruits and vegetable wastes will thus reduce the requirement of more land in near future thereby creating better environments, and reducing ecological risk (Mane and Raskar 2012).

In a study by Nithya and Lekeshmanaswamy (2010) vermicompost showed higher percentage of biomass production in the vermicompost medium as compared to the garden soil.

In yet another study, scientists have devised a low-maintenance vermicomposting system for processing manure and food waste for small-holder farmers. This system was first set up for treating cow manure and food waste in Kampala, Uganda, and monitored for approx. 6 months. The rate of biomass degradation and protein production were observed and calculated after every 2 months and finally at the end of the experiment. The organic biomass was reduced by around 46% and waste-to-biomass conversion rate was around 4% on a total solid basis. However, the conversion rate can be increased by increasing the frequency of worm harvesting. Thus it can be safely concluded from the above study that vermicomposting is an effective and economically viable manure management method for a small-scale agriculture. It was also found during the study that the return of investment is 280% for treating the cow manure of a 450 kg. Although the vermicompost is not sanitized, but the hygiene quality can be improved by including a post-stabilization step in which no fresh material is added. The animal feed protein generated in the process can be used as an incentive to improve current manure management strategies (Lalander et al. 2015).

In another study, vermicompost was also shown to play the role in reducing the heavy metal content in polluted soils in Thai region. The experiment was conducted using vermicompost at various concentrations of cadmium as cadmium chloride. The change/decrease in cadmium content was calculated by analyzing the physico-chemical properties of soil before and after the treatment with compost and vermicompost. The promising results were obtained showing that vermicompost absorbed more cadmium in sludge waste and subsequently reduced the cadmium concentration as compared to compost alone. The earthworms in vermicompost increased the pH of soil, the availability of P, K, Na, Mg, Ca while the content of organic carbon and cadmium contamination in soil were decreased (Nuntawut et al. 2010).

In yet another study, scientists studied the various integrated approaches available for different composting methods for the management of solid waste. Composting is not only a method for waste disposal but also includes waste recycling that can be used for agricultural purposes. The experiment was carried out in the following steps. The solid waste was first composted for 22 days that was further subjected to vermicomposting. Samples were routinely analyzed for the change in content of carbon, nitrogen, moisture, pH and temperature in order to determine the quality of composting. Besides this, decrease in moisture content to around 32%, and relative decrease in carbon and nitrogen content were also observed. Among the different types of treatment studied, only the mixture of municipal solid waste and activated sludge integration showed promising results that was followed by vermicomposting of mixture of municipal solid waste and activated sludge combination. All the results were compared to the other combinations used such as mixture of dried activated sludge, municipal solid waste plus activated sludge semisolid and municipal solid waste plus sewage water. All these results proved that windrow composting method followed by vermicomposting is an effective alternative as compared to other methods (Kumaresan et al. 2016).

Conventionally, vermicomposting is done manually by the farmers in their fields but research has improved and mechanized the production methods of earthworms and their castings. A mechanized process through a continuous flow reactor was developed that employs an elevated bed that allows the feedstock addition at the top level up to a height with 1–2 m thick bed of earthworms. These earthworms degrade the organic matter into 'castings' which are collected from below the bed, thus allowing the earthworms to work continuously with-out being disturbed. This in-vessel technology is more efficient than the customized windrow technology that is used in an outdoor environment and is subjected to variation in weather, predation, and moisture.

In yet another study, the comparison of effect of vermicompost with commercially available growth media) on plant growth was determined on an artificial synthetic media and soil. The research conclusion was that earthworms in the concentration of 10–20% produces optimum castings in media that resulted in improved root and shoot development, increase in leaf size, formation of flowers, increase in crop yield, and overall health of plants. They also produced certain antagonistic substances that helped from plant pathogens. The other recent findings on the functions of casting research are their insect-repellent properties, suggesting their potential to be used as an organic, non-toxic bio-pest repellent.

Vermicomposting can be used in treatment of wastewater residuals (bio-solids). Scientific studies have shown the nearly complete removal of four indicator species of human pathogens (*E. coli, Salmonella*, enteric viruses, helminth ova). It is still yet to be approved by USEPA or USDA as a safe and effective means for treatment of bio-solids for reducing pathogens (Vermico-http://www.vermico.com/vermicomposting-technology-for-waste-management-agriculture-an-executive-summary/).

Anwar et al. (2015) reported that application of compost prepared from a mixture of dairy manure with wheat straw and sawdust yielded higher plant biomass. However, compost prepared from cattle manure and rice straw contained high levels of total nitrogen and C/N ratio which is suitable to be used as soil amendment. Zhen et al. (2014) tried to reclaim degraded soils by applying manure compost and bacteria fertilizers alone or in combination on maize growth. They found that the number of microorganisms increased by the application of compost manure due to improved microbial activity and diversity of degraded irrigated lands. Ewulo et al. (2007) determined the effect of cow dung on soil, leaf mineral composition and pepper yield. The results showed that plant height, yield and fruit weight increased when cow dung was added up to 7.5 t ha^{-1}. Wani et al. (2013) observed that cow dung based compost, prepared by using the epigeic earthworm *Eisenia fetida*, contained high concentration of nitrogen, phosphorus and potassium nutrients compared to other waste materials. Ngakou et al. (2014) observed that the compost prepared from cow dung was higher in N, P and K contents as compared to kitchen manure.

Suthar (2008) studied the potential of the epigeic earthworm *Eisenia fetida* commonly used in vermicomposting for stabilization of sludge after being mixed with cow dung under laboratory conditions. It is found that all the vermicompost ponds showed a decline in organic carbon by 8–26% and pH by 8–19%; however and an increase in total nitrogen by 130–171%, available phosphorus by 22–121%, exchangeable potassium by 105–160%, exchangeable calcium by 49–118% and exchangeable magnesium by 14–51% content was observed. Thus it was concluded that *Eisenia fetida* maximized the degradation and mineralization efficacy in vermibeds showing it as a useful method for organic manure management. Garg and Kaushik (2005) found that earthworm population mortality was more in textile mill sludge vermibeds but it can be minimized by adding sufficient amount of cow dung or plant residues (Suthar 2007a). The other factors that affect the growth of earthworms are related to physiochemical and nutrient characteristics of waste feed stocks (Suthar 2007b).

Some studies have also shown that these earthworm species also secretes phosphatase enzyme in the soil during their decomposition activity and excreted through their cast deposition (Le Bayon and Binet 2006).

Previous studies indicated that vermicompost earthworms can help in the bioremediation of heavy metals (Gupta et al. 2005). Yamada et al. (2007) developed another method of composting cattle dung wastes that utilizes hyper-thermophilic pre-treatment reactor along with a general windrow post-treatment system.

15.8 Vermicomposting: International Appeal

Vermicomposting has a great international appeal. It is especially useful in areas where temperate weather conditions allow for implementation of outdoor systems. Besides India, where vermicomposting has been used for waste management and for the production of marketable castings; China utilizes these earthworms in their traditional medicines and also as pharmaceutical agents. Some of their clinical applications are in the treatment for diseases related to nervous, blood, cardiovascular, and respiratory systems. Earthworm treatments have been used for the treatment of conditions such as asthma, epilepsy, high blood pressure, schizophrenia, mumps, eczema, burns, ulcers and cancer.

In Cuba, vermicomposting animal manures has been practiced from the time as early as after the break-up from USSR and the loss of chemical fertilizers from the Soviet Union. In Australia, some researchers reported that these earthworms increased the grapes yield in vine yards by up to 35%. Similarly, increase in yield and fruit size of cherries by up to 25% was also observed with the use of earthworms for up to at least two annual harvests without further additions of vermicompost. Vermicomposting is practiced on large scale in countries like Mexico where more than 40 companies or individual farmers operate vermicomposting plants in 13 states. Their production capacities range from 0.3 to 4 tons/day of castings, chiefly from coffee pulp. Similarly, vermicompost can be used for damaged agriculture particularly in poor regions of Mexico. Its regular use can slowly improve the soil health and flora and at the same time can generate some income to rural farmers. Thus vermicomposting can be used as a social support and an ecological defense tool in developing countries (Gonzales and Morales 2002).

15.9 Conclusion

Vermicomposting technology is an old age practice in India and a well-known technology throughout the world. It represents an attractive, efficient and ecofriendly approach in treatment and management of solid wastes generated from all sources such as industrial, agricultural and domestic. The other added advantage is that in vermicomposting the material is neither landfilled nor burned but recycled. Thus, vermicomposting is a technology that focuses on conservation of resources and their sustainable utilization. Vermicomposting can also be used for the treatment of food-waste, paper, cardboard, manures, and bio-solids. It can be used in soil amendment. In addition, vermicomposting may also help in employment generation. Vermicompost can also be used in greenhouse application, in establishing new plants such as rootstock in vineyards. Vermicomposts can be used for both agricultural and horticultural production. However, there are still many research gaps that need to be addressed such as insufficient scientific study on enhancing the growth rate of earthworms.

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