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Vermicomposting - The Useful Technology for The Conversion of Biodegradable Wastes Into Desirable Products for Plants

***Abstract*: The undesirable enormous wastes created as a result of overgrowing population of this planet is increasing rapidly in the surface of soil causing pollution and affects the environment remarkably. These kinds of pollution significantly affect the various life forms. The biodegradable wastes may be used for the production of vermicompost to utilize it for the growth and development of plants. Such kind of organic fertilizers can be used effectively in both rural and urban areas. Vermicomposting is the useful to convert the biodegradable wastes to nutrient rich organic manure with the help of microorganisms and earthworms. Various species of earthworms and microorganisms plays important roles for the improvement of soil. The increasing use of inorganic fertilizer along with pesticides, insecticides etc. affect the environment adversely and also destroy the inherent properties of soil. The application of inorganic fertilizers for long time reduces the fertility of soil and is detrimental for future. Therefore, the use of these kinds of harmful substances should be reduced. Vermicompost made from biodegradable wastes in association with earthworms, microbes etc. provides essential nutrients for the plants. The article emphasized the exploitation of enormous biodegradable wastes to produce vermicompost considering various aspects of it like concept of vermicomposting, requirements, methods of production, process and dose of application, nutrients available in the vermicompost, advantages and disadvantages and precautions during vermicomposting.**

Keywords: Biodegradable wastes, earthworm, microbes, pollution, vermicompost

The population of this planet is increasing rapidly and creating enormous wastes. These kinds of wastes are increasing and deposited in the surface of the soil in unsafe ways. It may be biodegradable or non-biodegradable. The biodegradable wastes may effectively be utilized for the production of vermicompost which may be used domestically or commercially. The soil helps to enrich the growth of various flora and fauna. The merits and demerits of the soil are evaluated on the basis of important parameters like water holding capacity, nutrients, texture etc. The biotic components specifically earthworms and microbes play important role for the improvement of soil. Along with other components, earthworms and microbes are also important constituents of the soil. Indian subcontinent is the rich source of these farmers' friendly organisms. So there is an immense possibility to utilize these organisms in association with biodegradable wastes for the production of vermicompost to recognize its potential practical application.

Vermicompost is recommended as the pollution free and efficient technology for the enrichment of soil[1]. Both the biotic factors like earthworms, other worms, microbes etc. and abiotic factors like temperature, humidity, aeration etc. are interacted to form the compost[2]. The water holding capacity of this compost is high and the requirement of irrigation is also reduced because of its porous nature due to the proliferation of eggs of earthworms. So, indirectly, the fuel and electricity consumption may also be minimized.

The excretory products of earthworms and the decomposed bio wastes contain various nutrients which are intermingled with soil. The simple substances formed are available for the growth and development of plants. These kind of enriched nutritious products may also be utilized for the growth of beneficial microorganisms which in turn be used for the improvement of soil.

The use of inorganic fertilizers has increased enormously and affects the quality of soil, as a result of which it harms the whole ecosystem including the various life forms. The consumption of chemical fertilizer and the subsequent food grain production (Table 1) indicated that the production of food grain is not increasing proportionately enough as was expected with the increase in use of fertilizer[3].

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Table 1. Growth Rate in Fertilizer Consumption and Food Grains Production (1950 to 2012) (Praveen Desai et al, 2017)

Period	Growth rate in fertilizer Consumption (%)		Growth rate in food grains (%)	
	Total	Per Ha	Production	Yield
Pre-green revolution period (1950-51 to 1966-67)	19.41	18.11	2.56	1.45
Post-green revolution period	8.75	8.49	2.65	2.53
Phase I (1967-68 to 1980-81)	9.90	9.29	2.27	1.87
Phase II (1981-81 to 1991-92)	7.39	6.61	2.77	3.13
Post reforms Period (1991-92 to 2009-12)	3.98	3.69	1.33	1.38
8th Five Year Plan (1992 to 1997)	4.51	5.63	1.26	1.10
9th Five Year Plan (1997 to 2002)	1.35	0.43	-2.87	-0.98
10th Five Year Plan (2002 to 2007)	7.57	7.40	2.52	2.05
11th Five Year Plan (2007 to 2012)	5.52	7.55	2.77	2.90

Source: Fertilizer Statistics, FAI, (2012), Agricultural Statistics at a Glance, 2013

The increase of food production without hampering the environment is now the matter of discussion[7] and in this respect, the effective way to achieve it, is the use of organic fertilizer in combination with the chemical fertilizer.

The bioconversion of organic waste materials into nutritious compost using earthworms and microbes wastes were recognized[8, 9]. The potentiality to combat plant diseases has also been recognized[10]. Recently, an appropriate image quality evaluation system was evolved and the earthworm manure bioengineering was employed in practical approach[11].

The declining fertilizer response (Table 2) due to its constant use is an indicator of deterioration of soil health and loss of soil resilience capacity[4]. The soil health and its physical structure can be improved by the use of organic fertilizer.

Table 2. Declining Fertilizer Response Ratio in India during last Four Decades (Subba Rao et al. 2015)

Period	Fertilizer response (kg grain per kg nutrient used)
1970-71	49.79
1980-81	23.49
1990-91	14.06
2000-01	9.98
2010-11	8.69

Source: Economic Survey, Ministry of Finance, Government of India, (2014-15)

It was also reported that the rate of food production is not proportionate with the rate of increase consumption of fertilizer which indicates that nutrient use efficiency has been declining over time[5]. According to a report, one of the suggested measures to combat the declining trend of fertilizer response is the promotion of use of organic fertilizers[6].

The increasing use of chemical fertilizer helped to feed the county's overgrowing population, but the concern about its adverse effects on environment due to the indiscriminate use of chemical fertilizer is also growing.

The amount of global waste generation is increasing at an alarming rate which was 635 Mt in 1965 to 1999 Mt in 2015 and estimated to reach 3539 Mt by 2050. The treatment of waste in dumps declines, while the sustainable process of composting, recycling etc. increases[12].

This article emphasizes the productive exploitation of this technology of vermicomposting with the following objectives: i) to utilize the biodegradable wastes created by the overgrowing population to produce vermicompost ii) to reduce the use of harmful inorganic fertilizers as far as possible and to use the vermicompost in combination with chemical fertilizer iii) to improve the biological, physical and chemical conditions of soil and iv) to make awareness to produce and use vermicompost.

Concept of Vermicomposting: Vermicomposting is the mesophilic bioconversion process involving earthworms and microbes. The earthworms inhabiting the wastes consume the biomass and excrete the materials after digestion which is mixed with it that contains important nutrients and growth promoting substances. Over 3600 different types of earthworms found in the world, there are three ecological categories of earthworms: epigeics, endogeics and anecics, and among them the former has a role in litter transformation while the latter two have an impact on properties and processing of soil. But in general, they are categorized into two groups – burrowing and non-burrowing. The burrowing type like *Pertima elongata* and *Pertima asiatica* are pale in colour, 20-30 cm long and are present deep in the soil, whereas, the non-burrowing type like *Eisenia fetida* and *Eudrilus eugenae* are red or purple in colour, 10-15 cm long and inhabit in the surface of soil. These earthworms consume the soil and organic wastes and convert it into usable product utilizing the microflora of guts[13]. A wide range of feeding materials are used for earthworms during vermicomposting like animal dung specially cow dung, cattle manure, poultry droppings, plant leaves, pulp residues, fruit residues, water hyacinth etc.

The mucus of gut of earthworm contains various nutrient substances along with symbiotic microbes. The nutrients available in the gut along with moisture content make the environment favourable for the growth and reproduction of microorganisms. Moreover, the digestive enzymes like amylase, cellulase, protease, lipase, chitinase, etc present in the gut are helpful to convert the complex molecules of organic wastes. Only a small portion of ingested materials is absorbed by the tissues of earthworms for their growth and development, while a portion of organic wastes eaten are excreted in half digested form[14]. The microorganisms, enzymes and hormones of the gut of earthworms assist in rapid decomposition of half-digested substances and finally transform it into usable end product within a short period[13]. The normal composting process involving microorganisms alone required more time as compared to vermicompost[15]. The organic substances during its passing through the gizzard is grounded into a fine materials and then the microbes, digestive enzymes and other fermenting materials in the gut triggers its further breakdown and processing and finally, with the help of microbes, convert into vermicompost[16].

Methods of Vermicomposting: Among the various methods available, the bed and pit methods are quite common. In the bed method, the composting is processed on the floor through the formation of beds of organic mixture, while in the pit method, it is done in the cemented or similar other pits.

Requirements for Vermicomposting: Land, storage place, shaded area, earthworms, tanks or pits, fencing wire, water, agricultural/vegetables garbage like fruits, vegetables, leaves, peels, tea bags, grains, sewage sludge, agricultural wastes, grocery wastes, kitchen wastes, cafeteria wastes, ash etc., animal dung, dust soil, Slurry, working area with pillars and roof covered with straw, working chamber made by bricks and cement and/or beds of standard sizes, microorganisms, micronutrients, kodal, belcha, stitching machine, carry bags for storage, pan balance, earthworms, sludge and slurry, urine of cattle, field workers etc.

Methods of Production : The vermicompost is produced in a specialized tank made of bricks and cement. Tanks may be used with suitable dimensions. The tank is covered with various layers containing the raw materials of biowastes. The extreme bottom of the tank may be covered with plastic sheet or similar other material. The lower most layer is covered with the plant products like chaffy leaves followed by a thick layer of organic residues of various chopped materials which are mixed properly. The next layer of it is with animal dung and other wastes. The earthworms are then mixed with it. The mouth of the chamber or tank is covered with cow dung and soil. Water should be sprinkled after the release of worms. The mixture is then allowed to decompose for few days[13]. The application of water should have been stopped prior to harvesting the compost from the chambers.

After a couple of weeks, the compost becomes dust like blackish brown in colour, which indicates it is prepared and ready for use. The vermicompost produced in this way is sieved and then stored in go-down having with proper aeration. The produced is then packaged in the carry- or gunny- bags of different sizes for using it domestically and/or commercially. The production may be increased ranging medium to large scales according to the requirements of use for domestic and/or commercial purposes. It may also be used as an alternative to farmyard manure to improve the physical properties and biological activities of soil[17].

Nutrients Availability in the Vermicompost: The nutrients available in the compost depend on the raw materials used as biowastes, microorganisms and earthworms involved. All important macro- and micronutrients are available with desirable quantities in the vermicompost. These nutrients are very much effective and readily available for the growth and development of plants. The profile of nutrients is quite superior to that of normal garden compost (Table 3)[13].

Process and Dose of Application: The process of application of vermicompost depends on the type of crops and season of cultivation. Generally, in fruit crops, it is applied in the base of the plant, whereas, in ornamental plants or seedlings, it is used in the pots or beds together with soil. For field crops, it is generally applied through spreading in the field to mix it with soil. The dose of application may vary according to the nature of crops. Generally, for field crop, 2-3 t/ha of vermicompost and for fruit tree, 5-10 kg per plant is recommended[13].

Advantages of Vermicomposting: Vermicomposting is the easily adoptable, effective and low-cost technology

Table 3. Macro and Micro-nutrients Composition of Vermicompost and Normal Garden Compost (Nagavallemma et al, 2006)

Nutrients	In Vermicompost (%)	In Garden Compost (%)
Organic carbon	9.8–13.4	12.2
Nitrogen	0.51–1.61	0.8
Phosphorus	0.19–1.02	0.35
Potassium	0.15–0.73	0.48
Calcium	1.18–7.61	2.27
Magnesium	0.093–0.568	0.57
Sodium	0.058–0.158	<0.01
Zinc	0.0012	0.0012
Copper	0.0026–0.0048	0.0017
Iron	0.2050–1.3313	1.1690
Manganese	0.0105–0.2038	0.0414

for efficient bioconversion to transform the organic wastes, plant and animal residues into organic fertilizer. It is an environmentally safe and economically viable project which can also generate employment for low to medium skilled workers. Vermicompost is more nutritive than traditional compost made from cow dung[18]. The duration of nutrient retention capacity is also much more in vermicompost. The aeration and water holding ability is good because of its highly porous nature[19]. The physico-chemical and biological properties of soil can be improved and the structural aggregation of soil can be enhanced to reduce the chances of soil erosion with the use of vermicompost[20]. In many developing countries, the farmers can rarely afford to procure the inorganic fertilizers because of its high price and scarcity[21]. So, the use of organic fertilizer alone or in combination with chemical fertilizers may be useful.

Demerits of Vermicomposting: The whole process of vermicomposting is a laborious and time consuming job. Extreme care is needed in each step of its production. High amount of plant litters and animal products are required to form compost. But, in the recent scenario, collection of such materials particularly the animal dung is very difficult, which are not easily available. The marketing channel of vermicompost needs to be strengthened and its timely availability, as it is used as basal dose, required to be assured. Moreover, the farmers are not so much interested in the use of vermicompost as they do not have awareness of its full potential benefits which is realized slowly, compared to quick and magical effects of nutrients-rich chemical fertilizers.

Precaution: The process of formation along with the raw materials used should be checked, verified and implemented in the proper way to maintain the quality of the products. The earthworms and microbes are the most important components in this project. Generally, *Eisenia fetida* and *Eudrilus eugane* are used for making vermicompost[2]. So care should be taken for their normal growth and development. Extreme conditions like high or low temperature may affect them adversely. Standard moisture, aeration and humidity must be maintained throughout the process because the excess or inadequate moisture content of the compost as well as un-hygienic water may harm the survival abilities of organisms and adversely affect the composting process. Plant materials are preferably used for the production of vermicompost, while the materials of animal origin like bones, egg shells etc. may be avoided. The non-degradable waste materials must be avoided to produce vermicompost. Care should be taken to secure the earthworms from its predators.

Conclusion: The increasing growth of population along with economic reforms may insist the exploitation of eco-friendly services and can increase the demand of desirable outcome products. The bio-wastes which are the direct outcome could directly transform wastes to resources. The soil bio-engineer i.e. earthworms are the nature's gift involved in the noble work of bioconversion. This kind of easily adoptable technology may be the significant approach to reduce the load of harmful inorganic substances and generate employment. Thus, there is an immense scope to exploit it for the benefit of human beings and nature. ❐

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