Effective Conversion of Organic Wastes into Natural Fertilizers Using Vermicomposting

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Abstract

Disposal of Municipal Solid Waste is a big challenge in recent time for all developing countries due to rapid growth of population, indiscriminate growth of urbanization and wrong agricultural practices. Defective disposal method and improper management of organic wastes become a root cause for environmental pollution, global climatic changes and human health issues. The best possible alternative to reduce these potential pollutants and recycle them into organic manure is through vermicomposting. The major factors like moisture content, bulk density, C/N ratio, pH value and aerobic conditions are need to be optimised to show a better result for vermicomposting. Vermicomposting is regarded as an environmentally friendly, economically viable and socially acceptable technology all over the world. The current review emphasises on techniques of conversion of organic wastes into high quality vermicompost, factors affecting and applications of vermicompost and future prospects.

Keywords: Organic Wastes, Vermicomposting, Aerobic condition, Bulk Density.

1. Introduction

The statistical data reveals that due to uncontrolled population, rapid urbanization, industrialization, mechanized based farming have been adopted since last few years. Such farming encourages the use of commercial fertilizer in a large manner to gain profit in crop harvesting. Due to lack of modern store houses, certain amount of crops being wasted and treated as SOW. Generally, tropical soils are deficient in all necessary plant nutrients and on the other hand large quantities of such nutrients available in SOW. Treatment of Solid Organic Wastes(SOW) has therefore become a crucial thing all over the world, the speedy increase in their quantity and the mixing of biodegradable and non-biodegradable wastes at the points of formation make it troublesome to handle them with finite convenient resources. The overall objective of SOW management is to minimize the injurious environmental effects caused by the indiscriminate dumping of SOWs.Low level of soil fertility is one of the main constraints in boosting up agricultural production in India. The energy crisis in the country has resulted in increase in the price of commercial fertilizers which put a negative impact on small and marginal farmers. Insuch situation, recycling of waste is the only alternative for providing a renewable supplementary and continuous source of nutrients for crop plant in the countryside. In India crop residues, tree wastes, animal wastes, urban and rural wastes, agro-industries by-products etc are the dominant manorial resources and can be converted into bio-fertilizers if used scientifically. Otherwise, these wastes causeenvironmental problems like foul smell, occupying large spaces, production of disease carrier microbes. Biological material like earthworm i.e. ‘ploughman of the earth’ is a boon to minimize the pollution caused by mismanagement of these organic wastes by enhancing the process of degradation of complex substance. One approach towards solving the problem is regarded as Vermi-Composting. It is essential to use relevant species of earthworms in waste management. These vermi resources have vast and diversified potentials for waste recycle bio-fertilizer production, land reclamations, environmental detoxification and food sources. These bio- fertilizers can replace chemical fertilizer to some extent and create a better environment for the growth of plants. Vermi-Composting technology has gained momentum in recent years due to its multiple benefits. It is an eco-friendly and cost-effective technology using earthworms as bio-reactors for converting organic materials into valuable compost which is known as Vermi-Compost. The cost of crop production may be reduced significantly if vermicompost are integrated in nutrient management in agricultural field. Research on vermicomposting by using various wastes has been successfully going on throughout the world. There are number of earthworm species present in the soil and among them indigenous species are better adapted to local area. So choosing a suitable earthworm species for that particular area is the first important step of any vermicomposting activity.

2. Materials & Methods

Earthworms constitute a major component in soil functioning and they play an important role in chemical element transformations. Earthworms are important members of terrestrial ecosystems, aiding the maintenance of soil aeration, permeability, organic matter and soil structure, consuming large quantities of soil in the process. They are also primary consumers in terrestrial food chains and are prey for many small mammals and birds. For these reasons earthworms are commonly employed as an ecosystem indicator-species in eco-toxicological studies on soil contaminants.

Six earthworm species have been identified as potentially the most useful species to break down organic wastes. These are E. foetida (closely-related Eiseniaandrei), endrobaenaveneta, and Lumbricusrubellus from temperature regions and Eudriluseugeniae, Perionyx excavatusand Perionyx hawayanafrom the tropics. The optimum temperatures for E. eugeniae and P. xcavatus were also about 25°C, but they died at temperatures below 9°C and above 35°C.

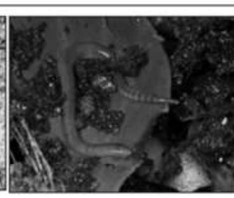
Types of Earthworms	Red Earthworm (*Lumbricus Rubellus*)	Tiger Earthworm (*Eisenia foetida*)	Blue Earthworm (*Perionyx Excavatus*)	African Night Crawler (*Pudrilus eugeniae*)
Pictures				
Length (mm)	35-100	50-100	4-100	150-200

Fig1. Different Types of Earthworm Species

The use of organic matter such as animal manures, human waste, food wastes, yard wastes, sewage sludges and composts has long been recognized in agriculture as beneficial for plant growth and yield and the maintenance of soil fertility. Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard and derive their nourishment from microorganisms that grow upon them. The end product, commonly referred to as vermicompost is greatly humified through the fragmentation of the parent organic materials by earthworm sand colonization by microorganisms (Arancon and Edwards, 2005). Vermicompost contains 'humus' excreted by worms which makes it markedly different from other organic fertilizers. It takes several years for soil or any organic matter to decompose to form humus while earthworms secrete humus in its excreta. Without humus, plants cannot grow and survive.

The humic and fulvic acids in humus are essential to plants in four basic ways; enables plant to extract nutrients from soil, help to dissolve unresolved minerals to make organic matter ready for plants to use, Stimulates root growth and Helps plants overcome stress. Presence of humus in soil even helps chemical fertilizers to work better. Humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize roots. Humus in vermicast extracts 'toxins', 'harmful fungi and bacteria' from soil and protects plants.

2.1 Compost preparation

A mixture of plant residues from Prunus dulcis and cattle manure in 5:1 (W/V) ratio is used for earthworm (P.excavatus) compost preparation. The organic residues are mixedand earthworms were added at a ratio of 5 kg worms per m^3 of organic residue. A bed of worms and organic residues is first prepared in a container and additional layers of organic residue are subsequently distributed over the pile at times depending on the temperature until the pile reached 50 cm. At the end of transformation process (3 months after distribution of the last organic residues), the worms need to be removed by placing a pile of fresh organic residue (plant and cattle manure) in a corner of the container.

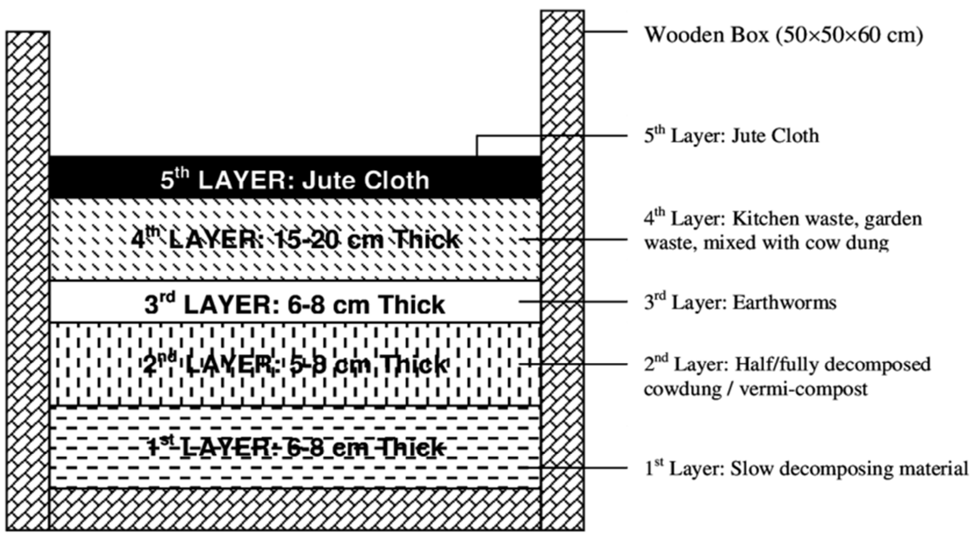


Fig.2 Vermi-Compost bean Preparation

2.2 Extraction of Humic acid

Humic substances are the components of humus and as such as high molecular weight compounds that together form the brown to black hydrophilic, molecularly flexible, polyelectrolytes called humus. Humic acids comprise a mixture of weak aliphatic (carbon chains) and aromatic (carbon rings) organic acids which are not soluble in water under acid conditions but are soluble in water under alkaline conditions.

The humic acid is extracted by 10 volumes of 0.5 mol L-1 NaOH (Sodium Hydroxide) is mixed with 1 volume of earthworm compost, under N_2 atmosphere. After 12 hour, the suspension is centrifuged at 5000g and acidified to pH 1.5 using 6 mol /L of HCl.

The solubilisation and precipitation of HA were repeated three times and the last pellet was mixed with 10 volumes of a diluted mixture of HF-HCl solution (5 ml /L of HCl [12 M] + 5 ml/ L HF [48%, v/v]). After centrifugation (5000g) for 15 min, the sample was repeatedly washed with water followed by dialyzing against deionized water using a 12- to 14-kD cut off membrane. The dialyzate was lyophilized and characterized chemically. Then, the HA powder was solubulized with 50 to 100 ml of 0.05mol/ L NaOH and the pH was adjusted to 5.5 with 0.1 M HCl.

Table 1. Nutrient Analysis of the compost product (In % of Nutrient Content)

Type	N (Nitrogen %)	P (Phosphorus %)	K (Potassium %)
Poultry Manure	2-4	1-3	1-3
Feedlot Manure	2-3	1-1.5	1-2
Dairy Manure	1-2	0.5-1.5	1-2
Urban Yard Waste	1-1.5	0.2-0.5	0.5-1.5
Crop Residue	1.5-2.5	0.2-0.5	1-3

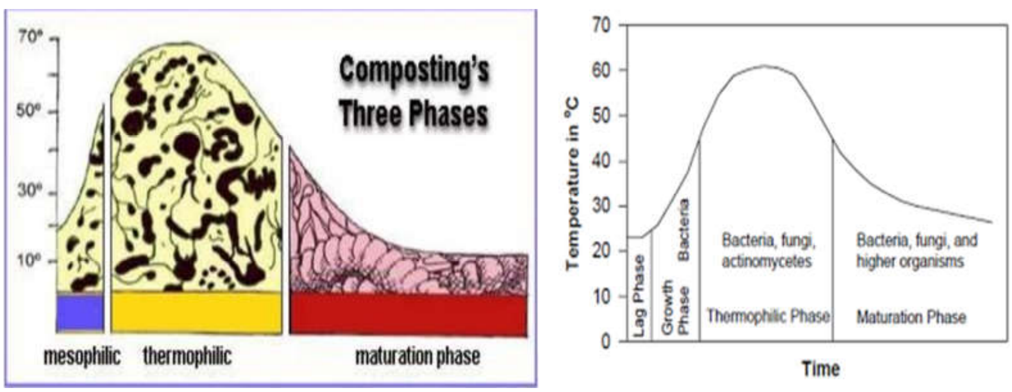


Fig.3 Phases of Composting

Table 2.Nutrient Content in Vermi-Compost Compared with Farm Yard Manure

Nutrient	Vermi-Compost	Farm Yard Manure
N %	1.6	0.5
P %	0.7	0.2
K %	0.8	0.5
Ca %	0.5	0.9
Mg %	0.2	0.2
Fe (ppm)	175.0	146.5
Cu (ppm)	5.0	2.8
Zn (ppm)	24.5	14.5
Mn (ppm)	96.5	69.0
C:N Ratio	15.5	31.3

3. Results and Discussion

It has been observed in separate preliminary experiment that earthworms do not survive in decaying fresh /pre-decomposed vegetable waste, pre-decomposed paper waste (PW) as well as in soil-sand mixture. Their performance is not satisfactory in pre-decomposed mixtures of vegetable waste and shredded paper waster. On the other hand, earthworms survive well in a mixture of these three waste stuffs. Thus it has been decided to use variable amount of rotting vegetable waste for mixing with 2kg of sieved soil-sand mixture and 1 kg of shredded paper in order to balance its moisture and nutrient content and C/N ratio. It was observed that the number of adult worms, total bio-number (Adults + baby worms+ juveniles + cocoons) and respective biomass increased with increasing amount of organic waste from 1 to 5 parts of the waste mixture. Thus the best results will get obtained in a ratio of organic waste, paper waste and soilsand mixture (5:1:2), in which there will be 664.43 % increase in worm population and 395.40 % increase in biomass which is better in comparison of their standard medium dung in which 635.56 % increase in worm population and 367.82 % increase in biomass. With further increase of organic waste, rather lesser number of worms, babies and cocoons and lesser amount of biomass indicating that excess of organic waste creates unsuitable conditions of pH, aeration, C/N ratio for the life of earthworms. However the excess of other wastes, paper and soil-sand is also not suitable for the worms and an optimum ratio of waste materials is required for satisfactory vermicomposting performance. It has been noticed that foul smell begins to emerge from the decaying waste biomass from 3rdday and the biomass gets heated. In organic waste alone, the foul smell is very strong, long-lasting and unbearable, while in mixtures of three wastes, the smell is mild and disappeared within 10 days. The temperature of the mixture also get cool down a faster rate. The pH of the organic waste is vary from acidic to basic (2.5 up to 9.5) during pre-decomposition and basic to neutral (9.5 up to 7.0) during vermicomposting. It has been proved that vermicompost is highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective farm input' against the 'destructive' chemical fertilizers which have destroyed the soil properties and decreased its natural fertility over the years. Vermicompost contains plant hormones like auxin and gibberellins and enzymes which are believed to stimulate plant growth and discourage plant pathogens. It improves the fertility and water holding capacity of the soil. It also enriches the soil with useful microorganisms which add different enzymes like phosphatases and celluloses to the soil.

3.1 Comparison of Vermi-Compost& Commercial Fertilizers

In case of Vermi-Compost;

- Increase organic matter.
- Improve aggregate stability
- Reduce Bulk density
- Increase water holding capacity
- Increase cation exchange capacity
- Enhance the soil microbial community
- Suppress soil pests
- Provide nutrients

Fig.4 Vermi Composting from Wastes

In case of Commercial Fertilizers;

- Crops grow better, but so do weeds. Therefore, herbicide sprays are required too.
- Better quality plants attract insects, so pesticides may be needed.
- Excess nitrogen from artificial fertilizer gets into water supplies, causing the water system hazardous.
- Chemicals needs to be used safely. In poorer countries, farmers can damage their health by applying fertilizers, pesticides and herbicides incorrectly.
- Artificial fertilizers, applied without organic additions, do not improve soil structure.

3.2 Several Parameters of Vermi-Compost

- C/N ratio= 30 %
- Moisture Content= 50-60 %
- pH Value= 6-8
- Temperature= 55 ^{0}C-75 ^{0}C
- Oxygen= 5-15 %

4. Conclusion

It may be concluded from the study that vegetable market waste or domestic organic wastes can be recycled at home level by amending with sand-soil and waste paper shredding in container or tank units. The method is simple, efficient, inexpensive and user friendly. The vermicompost of vegetable waste acts as an excellent base for the establishment and multiplication of beneficial or symbiotic microbes. It being a natural means of soil fertility management fits well into integrated plant nutrient management strategy for sustainable agriculture. The large scale practice of vermicomposting may have far reaching effect in environmental conservation, sustainable development and improving community health. Moreover, this waste management technology mediated by earthworms could also be utilized for self-employment, resource generation in rural areas and a big income generation resource especially in urban cities.

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