Vermicomposting of Leaf Litter Bombax Ceiba by using Epigeic Earthworm *Eudrilus Eugiene*

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Abstract:

Vermicompost considered as an excellent product since it is homogenous, has desirable aesthetics, has reduced level of contaminates, has plant growth hormones, higher level of soil enzymes, greater microbial population and tends to hold more nutrients over a longer period without adversely impacting the environment. A study has been conducted to assess the role of vermicomposting and carrying out plant nutrients analysis of composts delivered from leaf litter waste. Wastes were collected and subjected to pit- and vermi-composting using an exotic species of earthworm (*Eudrilus eugeniae)*. Aim of this paper to generate awareness in peoples towards simple method (vermicomposting) for clean up their surrounding through convert waste in to best. This approach was used in present study to decompose leaf waste of college campus in to valuable product. Leaf waste was crushed and mixed with cattle dung in a ratio of 50: 50. At the end of decomposition, vermicompost obtained in fine granular form which was harvested through fine sieve to get homogenous compost. The composts were harvested and analyzed for macro-nutrients (N, P, K, Mg, Ca, S) by employing the standard methods.

Keyword:

Earthworm, Vermicompost, Leaf Litter, Compost, Cowdung, Epigeic Earthworm,

Introduction

All organic stuff, including dead plant parts like leaves, blossoms, fruits, branches, barks, and stems, as well as living plant parts like seeds and fresh leaves, is referred to as litter (Klinge, 1970). Litter is a term that encompasses all organic matter. Litter decomposition is a significant phase in the biogeochemical cycling. The process involves the release of sequestered nutrients from litter to soil, so making them accessible to plants and soil micro-organisms (Waring and Schlesinger, 1985). Litter decomposition encompasses an intricate array of processes, wherein chemical, physical, and biological agents interact with diverse organic substrates that undergo continuous transformations.

Leaf litter has the ability to provide nutrients for agriculture, but this potential has not been utilized yet. (Govindarajan, M. et al., 2008). The accumulation of leaf litter is a problem that frequently occurs in the environment of residential areas. In most cases, the leaves that fall from the trees are either piled up and burned or they are disposed of along with the municipal solid garbage. Not only does the ash that is produced return part of the nitrogen, phosphorus, and organic carbon that was present in the litter to the soil, but it also loses a significant amount of these elements. Air pollution is also caused by the burning of trash and other waste. (S. Gajalaxmi, 2005; Abbasi 1999). According to Dash (1993), when leaf litter is left on the soil, it makes a substantial contribution to the protection and enrichment of the soil resources.

Leaf litter can be decomposed and the resulting compost can be utilized as a fertilizer or soil amendment, but its commercial value is rather low. As a result of this factor, a small number of individuals in urban and suburban areas are motivated to gather leaf litter and produce compost from it. However, vermicompost is far more expensive than compost, costing around three times as much. It is highly favored by farmers, particularly in developing nations, as a soil conditioner. In addition to supplying organic carbon and NPK to the soil, which compost also does, vermicompost is said to possess additional qualities of supplying enzymes and hormones that enhance plant growth. According to Gajalakshmi (2005), vermicompost is considered to have fewer pathogens compared to compost.

Vermicomposting is a process that utilizes worms to transform organic waste in animal, agricultural, and industrial wastes into valuable nutrients (Mishra S., 2003). The process of vermicomposting is a straightforward biotechnological method of composting by which organic waste is broken down into beneficial substances with the assistance of earthworm. In this method, specific species of earthworms are utilized to improve the performance of the waste conversion process and to generate a superior final product (Zorba, 1998; Edward et al., 1988). Vermicomposting is a process that involves the decomposition of organic wastes through the interaction of earthworms with microorganisms. The earthworm play a significant role in breaking down the organic waste in a natural system. This process creates organic manure, which can be used for agricultural purposes. Earthworms are saprophagous, detrivorous, geophagous, and microbiovorous, which means that they devour a wide variety of biodegradable debris and litter as well as microorganisms and then transform them into high-quality manure.

In the realm of soil sciences, vermicomposting is an old method, but in the field of biosolids and solid waste management, it is a fresh concept that offers tremendous promise in the field of ecological sanitation. Other names for vermicomposting include earthworm vermistabilization, worm composting, and annelic eating. The process entails intricate mechanical, chemical, and biological conversions. The method is characterized by its rapidity, controllability, cost-effectiveness, energy efficiency, and zero waste. Additionally, it efficiently recycles organic materials and nutrients (Buzie-Fru C A, 2010).

The vermicompost produced by earthworms possesses exceptional value, making it the most persuasive justification for engaging in vermicomposting. In 1882, Charles Darwin observed that earthworms had the ability to efficiently break down large amounts of plant debris, transforming it into nutrient-rich topsoil, which in turn promotes the growth of new plants. The waste contains nutrients such as nitrogen, potassium, phosphorus, and calcium. These nutrients are transformed into more soluble forms by microbial activity, making them easier for plants to absorb. Additionally, worms in the trash can be used as a protein source in animal feeds.

Earthworms are also credited with reducing soil compaction and enhancing permeability and aeration. Earthworms achieve this by their digging activities, the consumption of soil together with plant waste, and the subsequent excretion of casts. When the casts dry, they create soil aggregates that are resistant to water. Aggregates are clusters of soil particles held together by organic substances. Their existence enhances soil structure, prevents nutrient leaching, and mitigates erosion risks (Werner and Bugg, 1990). The cast, produced by worms after passing through their gut, not only serves as a highly nutritious and valuable soil additive, but also transforms the original raw material into a safe product. This process effectively eliminates or greatly reduces harmful pathogens found in animal manures, including human excreta (biosolids) (Shanoon N.W. 2009).

There exist over 3000 distinct species of earthworms worldwide. Tropical soils exhibit the most diversity of species, with a decreasing number of species as one moves towards the northern regions. **Epigeic** species inhabit the upper layers of soil that contain organic matter and consume significant quantities of litter that has not yet decomposed. These animals create temporary tunnels in the mineral soil for brief durations. They are susceptible to changes in climate and the presence of predators, and typically have a tiny size and short reproductive cycles. An illustrative instance is *Eisenia foetida*, also known as the redworm or manure worm, which is employed in the practice of vermicomposting (Bouche, 1977). Epigeics inhabit soil litter and the humus layer. Their main role is to act as efficient agents of comminution and fragmentation of the leaf litter that they transform into stabilized organic matter.

Bombax ceiba is a fast-growing, large deciduous buttressed tree with horizontally spreading branches in whorls having crimson, orange or yellow flowers clustered at end of branches, conspicuously present during spring season. Buttresses present only in trees of about 30 years of age and may extend 3-5 meters in height. The young branches and stems are covered with stout, hard prickles; bark pale ash to silver-gray, smooth in the early years, later becoming rough with irregular vertical cracks. The height of the tree is upto 40-meter-high and 6 meter or more in girth with horizontal branches and young stems covered with stout, hard prickles. The bark is pale ash to silver grey in color. Leaves are alternate, glabrous and digitate with 5 or 7 leaflets. It flowers when tree is leafless. Flowers are numerous, large, 10-13 cm in diameter, fleshy, bright crimson, red in color and numerous with copious nectar, bisexual, very rarely unisexual. Fruit is about 10 cm long, capsules oblong-ovoid, woody; seeds many, obovoid, smooth, 6-9 mm long, oily. Seeds embedded in dense wool. (Laxmi Raj Joshi), (Choudhary P. H.), (Prof. A. K. Das)

Materials and Methods

Bombax ceiba (Family-Bombacaceae) leaf litter is selected for the production of biofertilizer through vermicomposting. The leaf litter was collected from our college campus shade dried and used as organic waste. Urine free fresh cow manure (cow dung) was collected from Gaousala, Suratgarh.

Feed mixture having 1:1 ratio of leaf litter and cow dung will be established in plastic containers of appropriate size. This mixture will be turned over manually every 24 hours for 15 days. Ten non-ciliated earthworm *Eudrilus eugeniae* will be introduced in each container separately. All containers will be kept in darkness at room temperature. The moisture content of the feed in each container will be maintained at 60-80% throughout the study period by periodic sprinkling of adequate quantities of water. There will be three replicates for each feed mixture. Bedding will be monitored for their chemical changes and also for the earthworm biological changes from 0 to 120 days.

Periodic Physio-chemical analysis of vermicompost:

The physio-chemical characteristic of compost will be carried out periodically.

pH: The pH of the air-dried compost will be measured by digital pH meter taking the supernatant liquid of the soil solution.

Potassium: Potassium content of compost will be measured by digital Flame Photometer, using neutral ammonium acetate as extraction medium of compost.

Phosphorus: Phosphorus content of compost will be measured by colorimeter.

Organic Carbon: Total organic carbon content of air-dried compost will be measured by Walkley and Black (1934) method.

Nitrogen: Nitrogen content of the air-dried compost will be measured by Kjendal method (Brenner and Mulvaney,1982).

Calcium: Calcium content of the air-dried compost will be measured by Flame-Photometer.

Result and Discussion:

Table 1 displays the values of mature vermicompost derived from leaf litter. The data unambiguously demonstrated that the introduction of earthworms into leaf litter resulted in substantial alterations to the chemical makeup of the leaf litter.

The physic-chemical parameters, electrical conductivity, total phosphorus, total nitrogen, total potassium, and calcium were found to be higher than that of control while organic carbon and C/N ratio observed in the vermicompost decreased over control (Tabel). Vericomposting process accelerates the mineralization of N content in organic waste resources (Garg and Kaushik, 2005; Suthar, 2007; Prakash et. al, 2008). In the present study also the mineralization activity of the earthworm, *E. foetida* attributed to the increase of nutrients in vermicasts. The C/N ratio was found in the cast of *E.foetida*, lower than the C/N ratio recorded for control in study. The C:N ratio of organic waste material, which is one of most widely used indices for compost maturation, decreases sharply during Vermicomposting process. Release of part of the carbon as CO_2 in process of respiration and production of nitrogen lowers C:N ratio of the substrate (Suthar, 2007; Prakash et. al, 2008; Suthar, 2006).

In this study, the pH decreases from alkaline to acidic or neutral. The pH values were decreased in compost and vermicompost than initial materials, but pH of vermicompost was lesser than compost. The pH shifted toward acidic condition was attributed to mineralization of phosphorous and nitrogen into nitrates/nitrites and orthro-phosphates; bioconvergens of organic materials into intermediate species of organic acids (Ndegwa et. al 2000). The pH of the substrate is reduced by the microbial breakdown that occurs during Vermicomposting, which leads to the production of CO_2 and organic acid. (Garg, 2004; Haimi and Hutha, 1986; Elvira et. al, 1998; Hartensitien and Hartenstien, 1981) (Haimi & Hunta 1986; Ndegwa dt. al. 2000;Gorakh nath 2009; S. Suthar 2008).

The total nitrogen content of vermicompost was higher than that of compost and substrate. But the vermicompost prepared from the leaf litter showed a very high percentage of nitrogen then control. The enhancement of nitrogen in vermicompost was probably due to mineralization of the organic matter. Hang et. al. already reported that *Eisenia foetida* in cow dung slurry increased the nitrate-nitrogen content. Additionally, it has been proposed that earthworms contribute to the nitrogen levels of the substrate by introducing excretory products, mucus, body fluid, and enzymes from their digestive system (Suthar, 2007; Tripathi and Bhardwaj, 2004). A reduction in pH is also a significant influence in nitrogen retention, as this element is released as volatile ammonia at higher pH levels. (Hartenstein and Hartenstein, 1981).

The material that has been vermicomposted contains a higher concentration of nitrogen. Because earthworms are responsible for the nitrogen mineralization of wastes, the presence of worms in waste material significantly increases the quantity of nitrogen as a result of this process. The findings also revealed that earthworms contribute to the enhancement of nitrogen levels in the substrate through the addition of their excretory products, enzymes, body fluid, mucus, and even through the decomposition of the tissues of dead worms in the vermicomposting subsystem. (Suthar 2007a).

Organic carbon has showed a significant loss. % of organic carbon in compost made from leaf litter without earthworm has reduced from 38.767±0.153 to 25.73±0.153% at ending of 120 day of experiment whereas in vermicompost the reduction was from 38.767±0.153 % to 18.167±0.115% in case of *E. foetida*. In general, an organic carbon loss was obtained during vermicompost process (Kale et. al., Garg and kamhate). Similiarly, Gajalaxmi st. Al. (2008) reported a significant carbon reduction in leaf litter processed by *E. Eugeniae*. Garg et. al (2009) have reported that reduction in total organic carbon was highest in agro-residues treated with *E. Foetida*. Earthworm modify the substrate condition which consequently promotes the carbon loss

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from substrate via microbial respiration in form of CO_2 and even via mineralization of organic matter. According to Elvira et. al., a significant amount of organic matter in the starting material was converted into CO_2 during the vermicomposting process, resulting in a reduction of 20 to 43% of the total organic carbon by the end.

Electrical conductivity has shown increase in vermicompost and composts than initials. This shows that during vermicomposting process, the soluble salt level increases due to mineralization activity of microorganisms as well as earthworms in the organic substance and as well in earthworm's gut. Joshi and kelkar (1952) have reported a higher electrical conductivity of casts, which denotes upsurge in soluble salts in soil. These findings are well supported by outcomes of previous work conducted. (Daniel and Karmegam 1999; Karmegam and Daniewl 2001; Karmegam and Daniewl 2009).

Total phosphorus was greater in final compost and vermicompost than initial mixture and vermicompost contain higher quantity of phosphorus then compost also. Increased level of P throughout vermicomposting is because of earthworm-gut-derived phosphatise activity and also increased microbial activity in the cast (Lee and Foster 1991). Krishnamoorthy (1990) observed that the increase in the phosphorus (P) content during vermicomposting is likely a result of the breakdown and release of P through the activities of bacterial and fecal phosphatase enzymes produced by earthworms. Sharma & Aggarwal's research findings indicate that earthworm casts contain seven times the amount of phosphorus compared to regular soil. Garg et.al. (2005) observed a significant rise in phosphorus content, ranging from 1.4 to 6.5 times, in several substrates treated by *E. Foetida* compared to the control. According to Scubla et. al. (1998), phosphorus is initially bound in organic matter in a manner that is not accessible to plants. However, the mixing action of earthworms transforms it into a form that can be absorbed by plants. The reference is from Alagesan (2010). In their study, Bagan and Binet (2006) determined that the influence of earthworms on the biogeochemical transformation of phosphorus (P) in the soil is contingent upon the interplay between the characteristics of the organic P source and the specific burrowing behavior and dietary preferences of the worms (Suthar 2008).

This upsurge in T P could be attributed due to bacterial and faecal phosphatase activity of earthworms [Edward and Lofty 1972]. In their study, Mansell et al. (1981) discovered that earthworms contribute to an increase in accessible Phosphorus in plant litter through the physical

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breakdown of the plant material during feeding. Stachell and Martin (1984) reported that the rise in total protein (TP) was a result of the worms' gastrointestinal enzymes directly affecting it, as well as indirectly stimulating the microbiota. According to Barley and Jennings (1959), plant litter becomes more susceptible to decomposition by other organisms once it has undergone grinding and chemical alterations in the digestive system of earthworms.

Total potassium concentration was improved in both vermicompost as well as compost in comparison to initial substrate. After the conclusion of the experiments, it was shown that leaf litter composted by *E. Eugeniae* had a higher potassium content compared to the control group. Previous studies have also shown an increase in potassium concentration in vermicompost toward the end of the experiment. Delgado et. al have stated a greater content of total potassium in the new sewage sludge vermicompost. Benitez et. al studied that the leacheates collected throughout vermicomposting process had higher potassium concentration. Kaviraj & Sharma noted that the presence *of E. Foetida* resulted in a 10% rise in the overall potassium level, whereas L. Matuitti led to a 5% increase during the process of vermicomposting. Sharma & Aggarwal found that earthworm casts have eleven times the amount of potassium compared to regular compost. Baster et.al. identified that the increase in potassium is a result of the transformation of non-exchangeable form into an exchangeable form. Uma Maheshwari et.al. observed a similar upward trend in the potassium levels in the vermicompost produced by the activity of *E. Eugeniae*, as reported by Alagesan in 2010.

The vermicompost exhibited a greater concentration of calcium compared to both the compost and the initial feed mixture. The increased calcium concentration in vermicompost, as compared to compost and substrate, can be attributed to the catalytic activity of carbonic anhydrase found in the calciferous glands of earthworms. This enzyme facilitates the production of $CaCO_3$ when CO_2 is absorbed. The study by Gorakh Nath (2009) suggests that the gastrointestinal processes related to calcium metabolism play a key role in increasing the inorganic calcium content in worm cast. The increase in elevation could be attributed to the presence of microorganisms in the digestive system of earthworms and their associated metabolic activities (P. Alagesan 2010).

There was considerable increase in micronutrients level viz., copper, zinc, and iron in the vermicompost samples when matched with initial substrate and compost. The elevated level of Zn, Mn and Fe in vermicompost indicates acierated mineralization with selective feeding by earthworms on materials containing these metals. The waste material consumed by earthworms undergoes bio-chemical transformations, resulting in the production of casts that contain plant nutrients and growth-enhancing chemicals in a readily usable form. The increased nutrient levels are also influenced by enzymatic and microbial activities of the earthworms (M.S. Kitturmath, R. S. Giraddi 2007).

Sulphur is an essential dietary requirement for all animals and microbes because of its role in teh synthesis of sulphur containing amino acids and citamins. Copper and Iron are necessary for enzyme as well as haemoglobin formation (Lehninger et. al. 1996). The reduction or increase of macro and micro elements may be because of better utilization of these elements from consumed organic materials by the microbes as well as worms for their growths and reproduction. (Natchimuthu Karmegam, 2009)

Many investigators also stated decrease in sulphur level in vermicompost worked by different species of earthworms [Kale et al.,1994; Ramalingam and Ranganathan, 2001]. It is well known fact that sulphur is an essential dietary requirement for all animals because its part in production of sulphur containing amino acids and vitamins, so it can be determined that the reduction in the sulphur level of worms worked compost may be because of augmented demand of sulphur by these worms for their growth of biomass production. This result was also reported by Christy et al. (2005). Augmented level of micro as well as macronutrients in vermicompost were in conformity with the results of earlier works.

The C:N ratio was decreased in the final vermicompost by 32.11% from initial feed mixture. This decrease could be attributed due to the decomposition. This overall decrease in C:N ratio was associated with an increase in TKN and an increase of final worm worked product. The loss of Carbon as CO_2 in the process of respiration and production of mucus and nitrogenous excrements enhance the level of Nitrogen which lower the C:N ratio [Senapati et al. 1980]. According to Senesi (1989) decrease of C:N ratio to less than 20% indicates an advanced degree of organic matter stabilization and reflect a satisfactory degree of maturity of organic waste. Other researchers have observed similar findings. [Levi- Minzi et al. (1986); Bansal and kapoor (2000); Atiyeh et al. (2000).

Reduction in the C:P ratio in final vermicompost by 30.19% than initial material was reported (Table1) Lower organic carbon and decrease in TP could be results in the decrease in C:P

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ratio. During vermicomposting earthworms initially accelerated the decrease in C:P ratio due to mineralization of phosphorus into orthophosphorus and rapid decomposition of organic matter.

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Time	pH			N			OC			EC			Phosphorus			Potassium			Calcium		
	Cow Dung + Leaf Litter	Cow Dung + E. Eugiene	Cow Dung + Leaf Litter + E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter + E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter + E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter + E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter +E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter +E. Eugiene	Cow Dung + Leaf Litter	Cow Dung +E. Eugiene	Cow Dung + Leaf Litter +E. Eugiene
0	8.247	7.850	8.247	1.163	0.827	1.163	38.767	45.067	38.767	1.240	2.057	1.240	0.283	0.357	0.283	0.347	0.547	0.347	1.357	1.933	1.357
15	8.133	7.753	8.057	1.183	0.850	1.200	36.400	44.633	33.567	1.273	2.030	1.297	0.303	0.383	0.343	0.370	0.587	0.387	1.380	1.967	1.433
30	7.997	7.660	7.593	1.213	0.880	1.233	32.033	38.367	27.133	1.343	1.970	1.457	0.323	0.430	0.403	0.400	0.643	0.443	1.423	2.017	1.547
45	7.923	7.523	7.367	1.247	0.927	1.297	29.433	33.333	21.867	1.420	1.883	1.723	0.353	0.493	0.483	0.433	0.717	0.517	1.497	2.073	1.717
60	7.887	7.413	7.107	1.280	0.967	1.370	27.067	28.567	18.433	1.513	1.823	1.827	0.380	0.550	0.547	0.467	0.737	0.580	1.563	2.113	1.837
90	7.857	7.193	7.043	1.310	1.017	1.460	26.367	23.633	17.867	1.560	1.773	1.877	0.403	0.587	0.593	0.487	0.723	0.633	1.600	2.143	1.887
120	7.843	7.047	6.943	1.327	1.053	1.537	25.733	21.167	17.567	1.587	1.763	1.917	0.410	0.610	0.617	0.497	0.707	0.713	1.647	2.197	1.947