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Comparative Analysis of Composting and Vermicomposting from Peel of *Musa acuminata*

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Abstract: The biodiversity of agriculture is fascinating because different types of organisms depend on the habitat to fulfil basic needs like food, home, survival and reproduction. Banana cultivated farms and food consumption are interrelated with the context of industrial participation in a significant role simultaneously eliminating their waste products as solid waste. Banana peel, a solid waste in food industries, includes commercial and domestic wastes. These banana peels improve soil fertility by producing as compost. Vermicomposting is a good biofertilizer to enhance the plant's growth and yield. Various organisms from invertebrates to chordates were observed in banana cultivated farms. The study was carried out by banana peel and cow dung mixture in different treatments in composting and vermicomposting. The germination of fenugreek, green gram, and chickpea seeds for growth was maintained under aerobic conditions. Micro- and macro-nutrient contents were analyzed in both compost and vermicompost of banana peel using Field Emission Scanning Electron Microscope (FESEM). Based on the results, the composting was maintained for six weeks, and the vermicomposting of the treatments was carried out for three months as an effective biofertilizer for plants' growth and yield. Seed germination was calculated and the germination percentage was compared between compost and vermicompost. The amount of oxygen, silica and carbon is increased in compost, and the vermicompost is high in oxygen, silica, aluminium and carbon.

Keywords: Composting, *Eisenia fetida*, FESEM, Germination, *Musa acuminata*, Vermicomposting

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Introduction

India faces significant environmental problems due to waste generation, poor waste management, transportation, treatment, and disposal, which negatively affect the environment and public health (Adrija and Navni, 2018). Banana is scientifically known as *Musa sapientum* and belongs to the Musaceae family. Banana is a worldwide important crop, having local and large-

scale growers in every country. The global banana production is projected to be about 72.5 million metric tonnes, with India contributing 21.77 million metric tonnes. The peel is dumped as waste once the banana's inside pulp is consumed, posing an environmental danger due to the amount of nitrogen and phosphorus. Because of the vast amount of water in their formulation,

peels are highly perishable. Furthermore, both the pulps and peels contain a wide variety of vitamins and minerals (Morais *et al.*, 2017).

Composting is among the waste management strategies that are gaining interest as a suitable option for organic waste disposal with economic and environmental profits. The process leads to a stabilized final product, improving and maintaining soil quality and fertility (Larney and Hao, 2007). Composting of banana wastes to produce a stable fertilizer resource needs to be investigated as an alternative waste management pathway to landfilling for potential benefit to the resource-poor farmers. Application of crop residue compost to the soil is considered a good management practice because it stimulates the soil microbial growth and activity with the subsequent mineralization of plant nutrients (Eriksen, 2005).

Vermicomposting is a promising technology to convert a variety of bio-degradable wastes into organic fertilizer through interaction between earthworm and microorganisms, which break down the nutrient substrate from organic waste (Sharma and Garga, 2020; Sindhu and Annapoorani, 2021). Vermicompost effectively improves soil quality and enhances the microbial activity and nutrient recycling to produce high equality crops (Nurhidayati *et al.*, 2018). The vermicompost is a biofertilizer to the end-users like farmers for replacing chemical fertilizers and procuring better prices for the organic produce using such composting material (Ramnarain *et al.*, 2019). Earthworms are considered farmers' friends and an indicator of soil quality because they contribute enriched soil to an agricultural field. These worms are significant producers of natural manure without any factories and gifts to farmers (Annapoorani, 2014). The actions of earthworms in the vermicomposting include substrate aeration, mixing, grinding, fragmentation, enzymatic digestion, and the microbial decomposition of the substrate in the intestines of earthworms (Hand *et al.*, 1988;

Sharma *et al.*, 2005). The survival, biomass production and reproduction of earthworms are the best indicators to evaluate the vermicomposting process (Suthar, 2006). Biodiversity of agriculture knowledge is essential for understanding the food chain. The interrelation of organisms, human beings and industrial participation in various activities leads to dumping waste material. An attempt has been made in this study to report the work produced in banana cultivation farms like composting and vermicomposting banana peel using *Eisenia fetida* of different treatments and its compost using elemental analysis.

Materials and Methods

Biodiversity:

The photographs are collected from Bhavanisagar, Sathyamangalam, which is situated 76 km away from Erode, Tamil Nadu, India and lies 10°29'15" to 11°43'11" N latitude and 76°50'46" to 77°27'22"E longitude and this region is located in a strategically important area, connecting the two central biogeographical units, the Western and Eastern Ghats of India. Topography is highly variable with plains, slopes, hills, streams and rivers. The slopes and plains are subjected to a hot and dry climate. The average annual rainfall is 800 mm. The area is noted for sandalwood, *Santalum album*, Asian elephants (*Elephas maximus*), and a diversity of insects, amphibians, reptiles, arthropods, Annelids, and other flora and wildlife. The people in this area practice banana cultivated farms alongside the streams/rivers and plains. The collection of the organism in the study area was observed and recorded using photographs and identified using keys given by Pocock (1900) and Tikader (1982).

Collection and preparation of sample for composting:

The substrate for composting material was collected from banana cultivated farms, Bhavanisagar from Sathyamangalam. The selected Cavendish banana (*Musa acuminata*) peels were

cut into small pieces, shade dried for one week, and used for further experiments.

Experimental setup:

The experiment was designed to access the effect of various compost treatments formed from banana fruit peels (Table 1).

A sprinkling of water on compost was done both in the morning and evening. The experiment included six treatments (T1-T6) and control. The pit was dugged out in the ground with 1ft×1ft×1ft in size. The selected Cavendish banana (*Musa acuminata*) peel was placed in the first layer, cow dung mixture was placed in the second layer, which is maintained to fill the pit, and the fermented buttermilk was added to the hole for the better composting process. This set-up was closed by using coconut leaves for aeration. The compost's moisture content was kept constant. Temperature and pH were recorded till the end of the compost for 60 days.

Vermicompost using a compost of banana peel:

The compost of banana peel appears half-digested texture in each compost treatment, and young *Eisenia fetida* were inoculated. Experiments were conducted for a total of 30 days. Water was sprayed on the compost to keep it moist and create favorable circumstances (Ramalingam and Thilagar, 2000).

Experiment on seed germination:

Experiments were conducted at Zoology Laboratory for compost and vermicompost in different treatments. Control with varying treatments of compost using banana peel was used in the investigation. Fifteen seeds of fenugreek, green gram and chickpea seeds were sown in each coconut shell containing compost. A sprinkling of water is done every day. Seed germination was recorded and germination percentage was calculated as:

$$\text{Germination percentage \%} = \frac{\text{No. of seeds germinated in compost}}{\text{No. of seed germinated in control}} \times 100$$

Spectroscopic analysis:

The microstructures of the samples were determined using a Field Emission Scanning Electron Microscope (FESEM) (Carl Zeiss Merlin Compact 6073, Germany). Sample of compost and vermicompost were sputtered with gold for clear visibility of the images.

Results

Biodiversity of banana cultivated farms:

The biodiversity of banana farms at Bhavanisagar, Sathyamangalam region was observed for about 90 days. Various organisms such as earthworms, variety of insects, spiders, reptiles, birds, mammals were seen. The temperature and rainfall in that particular area were recorded—the climate of the Sathyamangalam region are shown in Table 2. The climatic condition of the Sathyamangalam region varies according to months-- winter season recorded by December to February and Flowering season by March and April.

Different species of organisms were observed. In the selected area, Annelids recorded was *Eisenia fetida* and the insects species were more in number like *Cosmopolites sordidus*, *Spodoptera litura*, *Acraea terpsichore*, *Alucophora indica*, *Schistocerca gregaria*, weevil, *Hycleus polymorphous*, *Gasteracantha fornicate*, only one Amphibiain species *Polypedates* were observed (Fig. 1).

Composting:

Green Banana peel is fibrous, and it expels water. It contains nitrogen-rich, potassium-rich, phosphorus-rich, and organic carbon-rich elements. Beneficial soil microbe colonies activate peel in a decomposed condition. They produce heat during the oxidation of organic matter, converting the peel into small, more straightforward pieces that resemble dirt and appear black under wet situations. After 60 days of compost, the ground seemed to be black; the compost is fully composted and is used as organic manure.

Table 1: Materials used for various treatments in compost

TREATMENTS	SOIL (g)	BANANA PEEL (g)	COW DUNG (g)
Control (C)	500 g	-	1.5 kg
Treatment (T1)	500 g	250 g	1.25 kg
Treatment (T2)	500 g	500 g	1 kg
Treatment (T3)	500 g	750 g	750 g
Treatment (T4)	500 g	1 kg	500 g
Treatment (T5)	500 g	1.25 kg	250 g
Treatment (T6)	500 g	1.5 kg	-

Table 2: Meteorological data from December 2020 to March 2021

Meteorological	December 2020	January 2021	February 2021	March 2021
Day time temperature	28.2 C	29.1 C	31.6 C	34.1 C
Nightly temperature	17.9 C	17.1 C	18.4 C	20.4 C
Average temperature	23 C	23.1 C	25 C	27.2 C
Daily sunshine	7.4 h	9.1 h	9.4 h	9.2 h
Average rainfall	46 mm	10 mm	12 mm	15 mm
Rainy days	2 days	0 days	1 days	1 days
Sea temperature	28 C	27.6 C	28 C	29 C
Humidity	72%	67%	63%	60%
Wind speed	10.1 kph	10.8 kph	10.4 kph	10.4 kph

Vermicomposting:

Vermicomposting is the method of making organic fertilizer using earthworms *Eisenia fetida*, which generally live in soil, eat biomass, and excreta of animals like cow dung through its digestive canal. The animal secretes digestive enzymes. After absorbing the nutrition into the bloodstream finally waste products expel to the exterior environment as vermicast. Vermicompost is the rich source of nutrients, vitamins, enzymes, antibiotics and growth hormones, micro- and macro-nutrients. It anchors the microbial

population.

Seed germination studies:

Germination of Fenugreek seeds in treatment T4 of vermicomposting was observed to be 95% as compared to compost treatment (80%). In green gram seeds, sprout was marked 90% high in treatment T3 and T4 compared to compost treatment T2 (80%). In Chickpea plants, more germination (90%) was noticed in vermicomposting treatment T3 compared to compost (80%) (Fig. 2).

Cosmopolites sordidus

Spodoptera litura

Acraea terpsicore

Alucophora indica

Schistocerca gregaria

weevil

Hycleus polymorphus

Gasteracantha fornicata

Polypedates

Turdus migratorius

Acridotheres tristis

Eisenia fetida

Fig. 1: Various organisms observed in banana cultivation farms.

Fig. 2: Effects of Compost and Vermicompost treatments on seed germination growth rates of fenugreek, green gram and chickpea seeds.

FESEM analysis in compost:

The structure of compost images in *Musa acuminata* of Treatment T4 (Fig. 3) and the different percentage of elements are given in Table 3. The germination result of compost was higher in treatment T4 than taken to elemental analysis through FESEM. The result showed that the amount of oxygen element was increased compared to silica and carbon. A medium amount of aluminium, magnesium, calcium and iron were present in compost in treatment T4. Potassium, titanium, cobalt and sodium were present at low level in compost. Spectral analysis of compost elements are shown in Figure 4.

Fig. 3: SEM images of compost in *Musa acuminata* (a) 20 µm and (b) 100 µm.

FESEM analysis in vermicompost:

The structure of vermicompost images in *Musa acuminata* of Treatment T4 (Fig. 5) and the different percentage of elements are given in Table 4. The germination result of vermicompost was higher in treatment T4 than taken to elemental analysis through FESEM. The given result showed that the amount of oxygen element was increased compared to silica, aluminium, and carbon. A medium amount of magnesium and calcium, potassium and iron were present in compost in treatment T4. Barium and titanium were present at a low level in compost and spectral analysis of vermicompost elements are shown in Figure 6.

Discussion

The Sathyamangalam Wildlife Sanctuary, previously known as the Sathyamangalam Forest

Division (10°29'15" to 11°43'11" N latitude and 76°50'46" to 77°27'22" E longitude), was designated as a Wildlife Sanctuary on December 3, 2008. This sanctuary is strategically essential and connects India's Western and the Eastern Ghats, two core biogeographical regions. The topography of the refuge is highly variable, with plains, slopes, hills, streams and rivers. The slopes and plains are subjected to a hot and dry climate. The average annual rainfall is 800 mm (Balasubramanian *et al.*, 2011). The present results coincide with the similar finding of biodiversity in banana farms.

The various treatments in managing the organic waste, such as landfill and incineration, decaying organic wastes using biological processes are considered a more suitable solution method. The composting process is circuit by microbial activity. Composting is an alternative solid waste management system; it can be used to recycle organic matter into valuable products. This process is considered the most efficient, environmentally safe, and most agronomically sound where compost can be used as a soil conditioner, organic fertilizer, and high nutrients for the soil (Kadir *et al.*, 2016). The study reveals the usage of banana peel as bio-compost which was decayed by biological process. Thus banana peel waste by composting is helpful product in solid waste management.

The compost has been reported as suitable matrix for seed germination. The enzymes help germinate the embryo by metabolizing the stored food like proteins inside the seeds into simpler monomers and transferring the same to the growing source (Paradelo *et al.*, 2012 and Joshi, 2018). This finding is supported by earlier studies which found that seed germination is good in compost soil and outstanding in vermicompost.

Vermicast may help germination of seeds and also improve plant growth as observed by using *E. euginae* (Annapoorani and Sindhu, 2019). The present study shows the similar performance of seed germination for plant growth. Amendment with compost is beneficial to soil quality since it

Table 3: Different elements present in compost of *Musa acuminata*

Element	Weight %	Atomic %	Net Int.	Error %	K ratio	Z	A	F
C K	27.22	38.50	91.34	9.97	0.0777	1.0768	0.2651	1.0000
O K	42.99	45.64	252.47	8.80	0.1409	1.0254	0.3197	1.0000
NaK	0.74	0.55	5.34	20.79	0.0033	0.9262	0.4798	1.0016
MK	1.54	1.08	17.72	9.47	0.0093	0.9406	0.6379	1.0029
AlK	5.33	3.36	68.02	5.63	0.0366	0.9045	0.7557	1.0040
SiK	12.43	7.52	169.94	4.28	0.0936	0.9231	0.8139	1.0025
K K	0.76	0.33	5.89	18.18	0.0065	0.8506	0.9753	1.0236
CaK	2.42	1.02	15.55	8.50	0.0211	0.8651	0.9869	1.0242
TiK	0.49	0.18	2.61	38.94	0.0040	0.7819	0.9974	1.0481
FeK	5.36	1.63	14.38	8.89	0.0435	0.7623	1.0072	1.0564
CoK	0.70	0.20	1.53	43.35	0.0056	0.7421	1.0069	1.0674

Fig. 4: EDX Spectra analysis of elemental peaking in compost.

(a)

(b)

Fig. 5: SEM images of vermicompost in *Musa acuminata* (a) 20 µm and (b) 100 µm.

Table 4: Different elements present in compost of *Musa acuminata*

Element	Weight %	Atomic %	Net Int.	Error %	K ratio	Z	A	F
C K	9.10	15.18	23.16	12.87	0.0205	1.1153	0.2022	1.0000
O K	46.50	58.18	322.17	8.12	0.1874	1.0633	0.3790	1.0000
MK	1.78	1.47	19.46	9.63	0.0106	0.9769	0.6074	1.0029
IK	7.11	5.28	86.68	5.75	0.0486	0.9397	0.7245	1.0041
SiK	19.63	13.99	255.52	4.38	0.1467	0.9593	0.7774	1.0024
KK	1.96	1.00	14.69	10.95	0.0169	0.8849	0.9516	1.0221
CaK	2.93	1.46	18.44	8.35	0.0261	0.9001	0.9655	1.0247
BaL	2.74	0.40	4.80	40.46	0.0182	0.6258	1.0594	1.0052
TiK	1.37	0.57	7.07	17.10	0.0114	0.8138	0.9840	1.0392
FeK	6.89	2.47	17.96	7.79	0.0566	0.7943	0.9990	1.0356

Fig. 6: EDX Spectra analysis of elemental peaking in vermicompost.

increases the availability of plant nutrients, improves physical properties, and stimulates biological activities (Kowaljow and Mazzarino, 2007; Hargreaves *et al.*, 2008; Hammer *et al.*, 2011). The present result coincides with the similar finding that compost is beneficial to soil quality for germination of seeds.

Nitrogen and phosphorus in all the treatments (T0 to T6) gradually increased. They obtained increased content of Potassium (K) in T3 to T6. Plants require N-P-K nutrients for growth. Chemical fertilizers boosted NPK for food

products, but it decreases the nutrient quality and affects soil fertility (Sindhu and Annapoorani, 2021). The result inverts proportionally as noted in case of composting of banana peel and vermicomposting in banana peel compost with a low amount of phosphorus element traced in FESEM result.

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