Journal of Applied and Natural Science
Special Issue: 14 (SI), 129 - 137 (July, 2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

A comparative study of effective microorganisms (EM) and biocompost in the decomposition of coconut waste material

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Article Info
https://doi.org/10.31018/jans.v14iSI.3598
Received: March 10, 2022
Revised: May 9, 2022
Accepted: June 2, 2022

How to Cite
Kumar, P. A. *et al.* (2022). A comparative study of effective microorganisms (EM) and biocompost in the decomposition of coconut waste material. *Journal of Applied and Natural Science*, 14 (SI), 129 - 137. https://doi.org/10.31018/jans.v14iSI.3598

Abstract
Lignocellulosic waste materials are recalcitrant in nature due to their interconnected complex polymer. Hence, composting of this type of lignocellulosic waste material is time consuming. This study aimed to compare the efficiency of effective microorganisms (EM) and biocompost in enhancing the decomposition of coconut waste.. A windrow heap of 3 x 2 x 1.5 m was prepared with alternate layers of coconut waste and cow dung. Two percent of effective microorganisms and biocompost were augment in each heap and the changes in the nutrient status of the compost across different composting time periods (15, 30, 45, 60, 75 and 90 days) were studied. It was observed that augmentation of both effective microorganisms and biocompost significantly reduced the organic carbon, while the total nitrogen, phosphorus and potassium increased on successive days of composting. At the end of study period, application of effective microoganisms (EM) reduced the organic carbon by 30.97%; and recorded the highest total nitrogen (1.20±0.024%), phosphorus (0.21±0.003%) and potassium (1.21±0.016%) content. Furthermore, augmenting effective microorganisms was highly effective, and the compost maturity was attained on the 60th day with a CN ratio of 17.8:1. The compost maturity test also validated that the effective microorganisms were more effective than biocompost in improving the rate of degradation of coconut waste and in producing mature compost of good quality.

Keywords: Biocompost, Coconut wastes, Composting, Effective microorganisms (EM), Lignocellulosic material, Nutrient transformation

INTRODUCTION

Agro wastes are one of the significant byproducts and have become an inevitable component to be managed in sustainable crop production (Bhuvaneshwari *et al*., 2019; Shyamsundar *et al*., 2019). During 2017 – 2018 nearly 516 million tonnes of crop residues were generated in India (Venkatramanan *et al*., 2021). The production of multiple value-added products from agro-residues and residue recovery from field conditions could address the deleterious environmental impacts resulting from processes such as burning of residues and could also have an advantageous impact on the nation's economy. The combination of lignin, cellulose and hemicellulose is termed 'lignocellulose'. It constitutes nearly half of the plant produced by photosynthesis and is the most abundant organic renewable resource in the world. Lignocellulosic materials mainly contain cellulose accompanied by hemicellulose and lignin. Cellulose and hemicellulose are made of distinct sugars, while lignin, an aromatic polymer, is produced from precursors of phenylpropanoids (Greff *et al*., 2022). Composting can dramatically decrease the presence of microbes that cause infection and can also replace synthetic fertilizers (Moss *et al.,* 2002). Finally, composting could provide a constant supply of nutrients taken up by crops during the growth cycle, thus helping to sustainably recycle nutrients. Degradation of these lignocellulosic materials is time consuming, and to catalyze decomposition, some amendments must be augmented during composting. Many lignocellulolytic microorganisms, most of which are fungi and bacteria, have been critical over the years in resolving this issue (Baldrian and Gabriel, 2003). For instance, various nitrogen fixing bacteria like Stenotrophomonas spp., *Azomonas agilis, Streptomyces spp., Bacillus spp.* and *Pseudomonas spp.,* produces lignocellulolytic enzyme capable of decomposing crop residues (Harindintwali *et al*., 2020). While there are large lignocellulolytic microbe collections, only a handful have been briefly examined (Lynd *et al*., 2002). Lignin will typically deteriorate or be converted thoroughly during composting since the degradation of lignin is hardly attributed to extensive mineralization in the compost system. The temperature, original lignin quality, and material thickness govern the deterioration of lignin in composts. Because of its complex existence, coconut waste is a recalcitrant lignocellulosic material.

The Indian share of coconut production ranks fourth worldwide. The annual production during 2019 – 20 was 20308.70 million nutswith a productivity of9345 nuts per hectare. . Kerala, followed by Tamil Nadu, Karnataka, Andhra Pradesh, and Odisha, has the highest produc-tive state in their country (CBD, 2021). The research was carried out at Rathnavel Subramaniam (RVS) Agricultural College, Thanjavur, Tamil Nadu, where coconut is one of the largest cultivated plantations and managing these wastes are quite challenging. Professor Teruo Higa from the University of Ryukyus, Okinawa, Japan, in 1971 developed the concept of effective microorganisms (EM). He established microbes that coexist and are physiologically compatible in mixed cultures. Introducing these cultures into the natural world improves their positive effects in a synergistic way (Crawford, 2002). Microbial inoculants have used many types of naturally beneficial microorganisms called "effective microorganisms" in the fields of nature and organic farming (Diver, 2001). To ensure that the introduced microbes maintain their dominance over the indigenous populations, a series of inoculations are administered. Photosynthetic bacteria, lactic acid bacteria, yeasts, actinomycetes, and fermenting fungus are the most common organisms. These include plant pathogen and disease suppression, energy conservation in plants, mineral solubilization, soil microbial-ecological balance, photosynthetic efficiency, and biological nitrogen fixation (Joshi *et al*., 2019). EMs can also be prepared from natural substrates and have various applications, such as agriculture, cattle, landscaping and gardening, composting, biological remediation, algal protection, septic cleaning, and domestic applications (Uma Maheswari and Anusuya, 2012; Nathaniel *et al*., 2020). Many trials have been reported to promote the efficacy of successful composting microorganisms (Uma Maheswari and Anusuya, 2012; Jusoh *et al*., 2013; Mathews and Gowrilekshmi, 2016 and Sreenivasan, 2013). The purpose of this analysis was to compare the performance of EM and biocompost for the coconut waste composting process and to determine the nutrient status at the end of composting.

MATERIALS AND METHODS

Collection and characterization of waste materials

Bulk samples of coconut waste from coconut fields were procured from Rathnavel Subramaniam (RVS) Farm, Thanjavur. Dried coconut leaves were the major constituent present in the waste. Larger wastes were shredded using a shredder to reduce their size and make them suitable for composting. Similarly, fresh cow dung was obtained from Animal Husbandry, RVSAC, Thanjavur.

Preparation of effective microorganisms and biocompost

Effective microorganisms and biocompost were commercially purchased. EM activation required dilution with 20 liters of water and jaggery (2 kg) to 1 liter of EM, and the content was kept for 10 days in a container at room temperature away from direct sunlight. The gas was released every day until fermentation ceased. Twenty milliliter of activated EM was taken in a hand sprayer and sprinkled on alternating layers by layer (Sreenivasan, 2013) of the compost bed. Similarly, biocompost was prepared at 2% concentration by mixing them with water.

Composting of coconut waste

The Windrow method was chosen for composting coconut waste. Window composting comprises depositing the raw material mixture in windrows or narrow long piles that are agitated or periodically turned. The turning phase blends the components and increases passive aeration (Harindintwali *et al*., 2020). The heap was prepared for 3 m long x 2 m wide x 1.5 m high. The coconut waste was spread uniformly at the prescribed length and breadth. On top of this coconut waste, cow dung slurry was added to initially stabilize the CN ratio to 30:1. Similarly, alternate layers of coconut waste and cow dung were added until the heap reached a height of 1.5 m. The treatment details are as follows. Effective microorganisms were added to T_2 intermittently after the addition of cow dung slurry, and similarly, biocompost was added to T_3. Finally, the top of each heap was covered with cow dung slurry. The moisture was maintained at 50 – 60% by daily watering. Turning was done once in 10 days for proper aeration.

The various treatments included T1 (coconut waste + cow dung (Control)), T_2 (coconut waste + cow dung + 2% effective microorganisms), and T3 (coconut waste + cow dung + 2% biocompost). The samples were drawn at different intervals (0, 15, 30, 45, 60, 75, and 90 days), and the changes in the nutrient status of the compost were analysed.

Analysis of nutrient status of the compost

The composting samples drawn at 15-day intervals were air-dried, powdered, sieved (0.2 mm) and analysed for pH, EC, N, P, K, organic carbon, and C/N ratio. The pH and electrical conductivity were measured using a pH meter and conductivity bridge at a ratio of 1:5 (solid:water suspension) (Jackson, 1973). The organic carbon of the sample was estimated using the chromic acid wet digestion method given by Walkley and Black (1934). Total nitrogen was estimated using diacid extract by following the Bremner method (Jackson, 1973). The total phosphorus and total potassium were also analysed using triacid extract. Total phosphorus was estimated by adding Barton's reagent, and yellow colour development was measured at 470 nm in a UV spectrophotometer. The potassium content was analysed by using a Flame Photometer (Jackson, 1973). The CN ratio was also calculated by dividing the carbon content by nitrogen content.

Compost maturing test

After 90 days, there was a reduction in the heap size and no odour, and the material was changed to black colour, indicating the maturity of the compost. Compost maturity refers to the stage at which they are converted into organic manure and hence can be applied to crops. The compost maturity test was conducted by adopting the following methods.

Harvesting the compost

After 60 days, the matured compost was disturbed and spread on the surface for curing. Therefore, even a small amount of heat present in the compost could be dissipated, and the compost became stable. Then, the composted material was sieved through a 4 mm sieve to obtain uniform compost (Mathur *et al.*, 1993).

Odour

The sample was collected, and if it has a damp earthy odour, it indicates the maturity of the compost, while the immature compost produces a foul odour (De Bertoldi and Zucconi, 1981).

CN ratio

It is the most important parameter to determine the maturity of the compost. The fully matured compost had a CN ratio less than 20, preferably on the order of 15 (Juste *et al.*, 1987).

Starch iodine test

Approximately 1 g of the sample was finely powdered in a beaker, and ethanol was added to moisten samples. Nearly 20 ml of perchloric acid was then added, stirred and filtered. The filtrate was then placed on a white tile, and few drops of iodine solution were added. A yellow colour is developed if the compost matures, while a dark colour with precipitation is developed if the compost is immature (Lossin, 1970).

Germination test

Water extracts of the compost were prepared by mixing the dried and sieved compost to distilled water at a ratio of 1:8 (W/W). The sample was then incubated. They were then centrifuged for 15 minutes at 1000 rpm, and green gram seeds were used as a test crop for assessing phytotoxicity. The seeds were placed in petri dishes at equal distances with filter paper soaked with the water extract of the compost, and the petriplates were incubated at 27°C under dark conditions. After 24 hours, the germination percentage was calculated (Zucconi *et al.*, 1981).

RESULTS AND DISCUSSION

The foundation of the research is the hypothesis that the use of EM and biocompost on coconut waste increases the activity of microbes and therefore escalates the composting process. It improves the mineralization of compost by improving the colonization and operation of microbes. To determine the effects of efficient microorganisms (EM) and biocompost on the increase in composting rates, a comparative analysis was performed to examine the effect of these hypotheses.

Characteristics of raw materials used for composting

Two raw materials, coconut waste and cow dung, were used in the study for composting (Table 1). The pH measured at 1:5 (solid water suspension) was higher in cow dung (8.25) than in coconut waste (5.68). The electrical conductivity (EC) measured at the same ratio

Table 1. Characteristics of coconut waste and cow dung

Characters	Coconut waste	Cow dung
pH (1: 5 solid water suspension)	5.68±0.08	8.25±0.20
EC (dS m^{-1}) (1: 5 solid water suspension)	4.21±0.02	2.32±0.05
Organic Carbon (%)	30.40±0.01	17.80±0.05
Total Nitrogen (%)	0.44±0.002	1.92±0.04
Total Phosphorus (%)	0.06±0.001	0.07±0.001
Total Potassium (%)	0.70±0.01	1.10±0.02
CN ratio	67:1	9:1

Values are mean of three replicates

was found to be higher in coconut waste (4.21 dS m^{-1}) than in cow dung (2.32 dS m^{-1}). The organic carbon and the CN ratio were much higher in coconut waste (30.40% and 67:1) than in cow dung (17.80% and 9:1). The total nitrogen and total phosphorus were found to be lower in coconut waste (0.44% and 0.06%) than in cow dung (1.92% and 0.07%). Coconut waste showed a higher potassium content than cow dung. The characteristics of coconut waste corroborate the findings of Tahir and Hamid (2012) who characterized the coconut waste collected from University of Malaya, Malaysia. Cow dung is an organic- and nitrogen-rich material; hence, the nitrogen content was high, whereas the CN ratio was found to be lower. Similar results were also reported by Nattudurai *et al.* (2014) and Pakvilai (2021).

Changes in pH across successive period of composting

pH is an important index for the chemical changes occurring in compost. During the 90 days of composting, pH showed slight changes in all treatments with no significant difference (Fig. 1). In all the treatments, the pH was observed to initially drop, after which it increased. This initial drop in pH reflects the formation of organic acids, which serve as a substrate for the subsequent microbial population (Ong *et al.,* 2001; Wang et al., 2016). The succeeding rise indicates the utilization of organic acids by microbes. Since the microbial population has risen, it was seen that the drop obtained during the first few days does not guarantee any lime addition (Ong *et al.,* 2001; Hachicha et al., 2009). This rise in pH may also be due to the degradation of soluble organic nitrogen-containing material, the development of ammonium ions and the liberation of hydroxide ions through hydrolysis (Uma Maheswari and Anusuya, 2012, Sanchez – Monedero *et al.,* 2001; Sundberg et al., 2013; Rastogi et al., 2020). Compost pH patterns were found in conjunction with Adediran *et al.* (2004) who observed a related pattern, whereby the pH initially decreased but increased later in a study in which tobacco waste along with saw dust and wood shavings were co-composted with pig dung, cow dung, cabbage waste or poultry manure. Similarly, during composting of home-scale organic wastes using effective microbes, a similar pattern was observed wherein the pH was acidic for the first two weeks. It turned neutral and then weakly alkaline, indicating the stability of organic matter (Van Fan et al., 2018). This trend in pH corroborated the findings of Mupondi *et al.* (2006), Zhong et al. (2018) and Sibomana et al. (2021).

Changes in organic carbon across successive periods of composting

Organic carbon decreased in all treatments throughout the composting period (Table 2). At the end of 90 days of composting, a 22.2% reduction in T_1 (Control), a 30.97% reduction with the application of effective microorganisms and a 22.15% reduction with the application of biocompost were observed. At the end of composting, the lowest organic carbon content was present in the compost amended with effective microorganisms. The decline in organic carbon is in line with the findings of Bhardwaj and Sharma (2015), Yadav and Gupta (2017) and Sandeep *et al.* (2017). The organic carbon loss might be attributed to carbon loss in the form of carbon dioxide and a rapid respiration rate. (Suthar, 2008; Hubbe et al., 2010; Van Fan et al., 2018). According to Tumuhairwe et al. (2009), substantial losses of organic carbon indicate extensive microbial activity in former organic carbon. This result corroborates the findings of Jusoh *et al.* (2013). Diaz *et al.* (1993) stated that carbon is a source of energy for cell build-up by microorganisms during composting. The microorganisms consume nearly all the biomass, and during the metabolism phase of the cells, they are transformed into CO_2. The membrane and protoplasm structure are formed from the left-over carbon content. This organic material needs to be broken down during the composting process by microorganisms, which oxidizes organic carbon into CO_2 under aerobic conditions and thus reduces the C/N ratio. Two-thirds of biomass is discharged into carbon dioxide during the decomposition of waste and the remaining biomass is stored as organic compost (Zhong *et al*., 2018; Joshi *et al*., 2019; Zainudin *et al*., 2022).

Changes in total nitrogen across successive periods of composting

For plants, nitrogen is one of the macronutrients. Bacterial metabolism can facilitate the transformation of organic forms of nitrogen into inorganic forms (NH_4^+, NO_3^-, NO_2^-) that plants may take in. In all treatments across different time periods of composting, the nitrogen content was observed to increase (Table 2). Nevertheless, the highest nitrogen content was observed in compost with effective microorganisms, while the lowest was in T_1 (Control). The decomposition rate and the nitrogen content of the initial feed material govern the nitrogen content of the final compost (Van Fan *et al*., 2018; Zhong et al., 2018; Joshi *et al.,* 2019). This may also be attributed to the improved mineralization of organic waste. Symbiotic microbes may, however, increase substrate mineralization (Atiyeh *et al.,* 2000). Additionally, the addition of nitrogen in the compost can be caused by organic carbon losses, pH modifications (Yadav and Garg 2011), decomposition of organic matter containing proteins and ammonium nitrogen transformations into nitrate (Atiyeh *et al.* 2000). According to Viel *et al*. (1987), the rise in nitrogen can be attributed to the depletion of dry mass from organic carbon to CO_2 during composting (Bishop and Godfrey, 1983). In addition, at the end of the composting phase, this rise in nitrogen value may be attributed to the use of nitrogen by microbes for cell development, thereby leading to a decline in nitrogen level. Subsequently, these organisms will die, and nitrogen is again recycled back, eventually increasing N (Polprasert, 1996). This increasing trend in nitrogen during composting is similar to the study reported by Jusoh *et al.* (2013).

Changes in the CN ratio across successive periods of composting

One of the vital indicators used for determining the rate of composting is the CN ratio since it can represent compost maturity (Bernal *et al.,* 1998). The findings showed that the CN ratio in all treatments decreased over the composting period (Fig. 2). The reduction in the C/N ratio was higher in the compost amended with effective microorganisms (41%), followed by the application of biocompost (31%) and the control (17.6%). This is because the decomposing microorganisms found in the effective microorganism consortia utilize the carbon and nitrogen content effectively relative to the control (Uma Maheswari and Anusuya, 2012). One explanation for the reduced CN ratio may be due to the loss of organic carbon in the form of CO_2 (Tahir and Hamid, 2012). A C/N ratio less than 20 is representative of advanced stability, appropriate maturity and agronomic applications. Likewise, in the present study, the compost obtained from coconut waste + cow dung + effective microorganisms (T_2) fell within these criteria, indicating a higher degree of stabilisation of organic matter. A reduction in the C/N ratio ensures that organic matter is decomposed and stabilized (Tripetchkul *et al.,* 2012). These results were in accordance with the studies reported on organic waste composting by Makan *et al.* (2012), Roca – Perez *et al.* (2009), Tumuhairwe *et al.* (2009), Jusoh *et al.* (2013) and Tripetchkul *et al.* (2012).

Changes in total phosphorus across successive periods of composting

A constant increase in the phosphorus content was recorded in all treatments throughout the composting process. On the 90th day of composting, the highest phosphorus content was observed with the application of effective microorganisms, followed by the amend-

Table 2. Changes in organic carbon and total nitrogen during various composting periods

	Organic carbon (%)			Total nitrogen (%)		
	T1	T2	T3	T1	T2	T3
0th day	31.51±0.55	31.32±0.24	31.23±0.51	0.94±0.012	0.90±0.003	0.93±0.005
15th day	31.53±0.48	31.16±0.60	30.20±.0.50	0.97±0.003	0.98±0.017	0.99±0.017
30th day	29.90±0.54	30.18±0.75	31.08±0.70	0.99±0.005	1.03±0.020	1.05±0.010
45th day	29.30±0.26	28.53±0.46	29.26±0.53	1.00±0.005	1.11±0.007	1.10±0.005
60th day	27.60±0.26	24.97±0.09	28.10±0.09	1.00±0.005	1.13±0.003	1.13±0.014
75th day	26.03±0.42	24.37±0.29	25.23±0.25	1.02±0.010	1.17±0.012	1.15±0.022
90th day	24.49±0.36	21.62±0.09	24.31±0.03	1.05±0.017	1.20±0.024	1.18±0.010

T_1 – Control (Coconut waste + Cow dung); T_2 – Coconut waste + cow dung + Effective Microorganisms (2%); T_3 – Coconut waste + cow dung + Biocompost (2%)

Table 3. Changes in total phosphorus and total potassium during various composting periods

	Total phosphorus (%)			Total potassium (%)		
	T1	T2	T3	T1	T2	T3
0^{th} day	0.05±0.003	0.06±0.002	0.05±0.002	0.85±0.012	0.83±0.014	0.83±0.041
15^{th} day	0.06±0.002	0.07±0.002	0.07±0.003	0.87±0.007	0.95±0.017	0.90±0.012
30^{th} day	0.06±0.002	0.10±0.003	0.09±0.001	0.91±0.005	1.08±0.005	1.04±0.017
45^{th} day	0.05±0.001	0.12±0.001	0.11±0.001	0.97±0.012	1.10±0.020	1.09±0.009
60^{th} day	0.06±0.001	0.15±0.002	0.14±0.003	1.00±0.012	1.15±0.011	1.10±0.022
75^{th} day	0.07±0.002	0.17±0.002	0.16±0.002	1.03±0.013	1.17±0.015	1.11±0.007
90^{th} day	0.08±0.001	0.21±0.003	0.19±0.001	1.05±0.012	1.21±0.016	1.18±0.016

T_1 – Control (Coconut waste + Cow dung); T_2 – Coconut waste + cow dung + Effective microorganisms (2%); T_3 – Coconut waste + cow dung + Biocompost (2%)

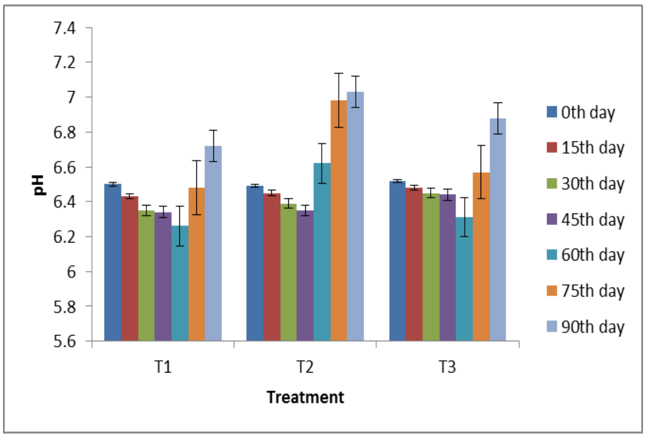

Fig. 1. *Effect of effective microorganisms and biocompost on changes in pH during 90 days of composting (T_1 – Control (coconut waste + cow dung); T_2 – coconut waste + cow dung + effective microorganisms (2%); T_3 – coconut waste + cow dung + biocompost (2%))*

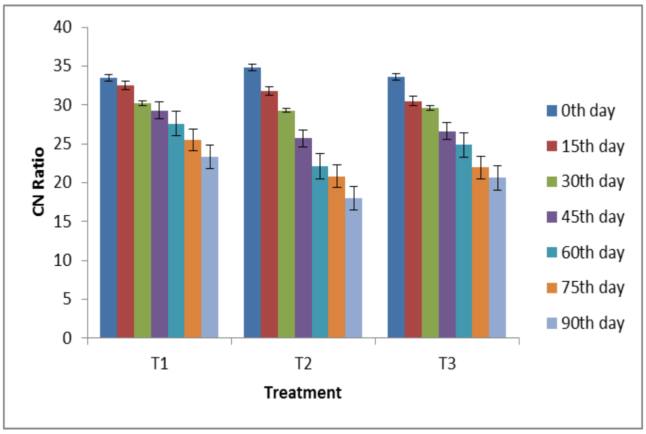

Fig. 2. Effects of microorganisms and biocompost on changes in the C/N ratio during 90 days of composting (*T_1 – Control (coconut waste + cow dung); T_2 – coconut waste + cow dung + effective microorganisms (2%); T_3 – coconut waste + cow dung + biocompost (2%))*

ment of biocompost in the compost pile (Table 3). This increased phosphorus content was due to mineralization of organic wastes accompanied by a reduction in the waste quantity under ideal conditions (Hubbe *et al.*, 2010; Rastogi *et al.*, 2020). Solubilizing phosphorus through phosphatase and microbial diversity may be the reason for the increase in the concentration of phosphorus (Garg *et al.,* 2006). The results are in accordance with the study reported by Vourinen and Saharinen (1997), Sommer (2001); Tai and He (2007) Van Fan *et al.* (2018); Zhong *et al*. (2018) and Joshi *et al.* (2019)

Changes in total potassium across successive periods of composting

The role of potassium in plant growth is to boost root elongation and ion balance, enhance protein synthesis, enhance enzyme reactions, and improve photosynthesis and dietary development (Jusoh *et al.,* 2013). In all treatments during composting, the potassium content was observed to increase (Table 3). After 60 days of composting, T_2 (coconut waste + cow dung + efficient microorganisms) revealed the highest potassium content of the compost, with a twofold increase, and the lowest potassium content was recorded in T1 (coconut waste + cow dung). Acid production during the decomposition process for the solvability of insoluble potassium by microorganisms may be the reason for the increased potassium content (Tahir and Hamid, 2012; Van Fan *et al*., 2018; Zhong *et al*., 2018; Joshi *et al*., 2019).

Compost maturity assessment

Starch iodine test

The starch iodine test is a possible experiment based on the assumption that the starch in the substratum reduces as the organic matter is destroyed, i.e., stability is improved. The reason for this is that starch is an easily decomposable ingredient, and thus, in an unstable substrate, its decomposition can improve the integrity of the waste. Hence, mature compost is devoid of starch content. The abundance of starch is one of the key compost stability indicators. A starch-iodine complex in an acidic extract of a compost substance was used to determine the starch concentration.

One of the potential tests is the starch iodine test, which relies on the hypothesis that the starch content present in the substrate reduces with the breakdown of organic matter, which in turn increases the stability. Therefore, mature compost will not have starch content. Subsequently, starch concentration is one of the major indicators of compost stability. Difficulties in avoiding false outcomes are related to the existence of commonly acceptable principles, which weaken the effectiveness of the starch test (Lossin, 1970). T2 (coconut waste + cow dung + efficient microbial organisms) turned yellow without any precipitate formation, indicating compost maturity. Its maturity also distinguishes it with its C/N ratio. The iodine starch test shows that the polymers were completely broken down. However, the precipitate formation in T3 and T1 suggested that it did not mature and that further stabilization and deterioration demanded a longer time for the compost.

Phytotoxicity test

Agricultural use of pesticides, industrial solvents and refrigerants produces many compounds that are detrimental to plant growth. Composting promotes the microbial breakdown of organic molecules that have phytotoxic potential and the bioavailability of composting organic matter. The phytotoxicity metrics in composts have been direct germination rates or adjusted germination indices (compare the germination rates for experiments and monitor growth media) (Pascual *et al.,* 1997 and Wu *et al.,* 2000). The highest rate of germination was above 90% (coconut waste + cow dung + efficient microorganisms), suggesting its maturity. The findings revealed that more than 80% of compost with germination was free of plant-toxic compounds, in agreement with Zucconi *et al.* (1981). Mahdi *et al.* (2007) showed similar findings in Chinese cabbage, where 82.5 percent germination showed a lack of phytotoxic compounds.

Conclusion

There is an immediate need for efficient and economic disposal of bulk organic waste. In this study, effective microorganisms were more effective in fastening the composting process of coconut waste than biocompost. Hence, effective microorganisms serve as an apt amendment for effective decomposition of lignocellulosic waste material. At the same time, value-added items from these wastes should also be produced. Composting is an alternative solid waste disposal technology. Lignocellulosic wastes are, however, complex in nature and require time to generate stable and mature compost. Some research has shown that the use of inoculants in composting processes may serve as a valuable tool to boost the humification of the end product and thus increase the farming efficiency of compost by achieving higher stability and maturity. One of the possible inoculants used to improve the decomposition rate of complex lignocellulosic materials such as cocoon waste was effective microorganism (EM). However, knowledge of various composting phases and the composition of the substrates are essential for basic composting inoculation and are best for the biodegradation of waste.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to RVS Agricultural College, Thanjavur, Tamil Nadu, for providing all facilities in conducting the experiment.

Conflict of interest

The authors declare that they have no conflict of interest.

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