

Article

A comparative study of assessing organic matter decomposition between composting and vermicomposting process

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Abstract: The aim of the study was to compare the efficiency of organic matter degradation between composting and vermicomposting as well as the possibility of making compost and vermicompost using cattle manure. The experiment was conducted with two treatments, where one was conventional composting (T₁) and another was vermicomposting (T₂) from cattle manure. The sample from composted materials was collected at 0, 20, 40 and 60th day of experiment. Parameter studied were dry matter (DM), crude fiber (CF), crude protein (CP), ether extract (EE), ash content of the samples as well as pH and temperature change during the experimental period. Results found that a significant higher DM (P<0.01) was found in T₁ compared to T₂. The CF degradation rate was significantly higher (P<0.01) in T₂ compared to T₁ group. The CP content also found significantly higher (P<0.05) in T₂ compared to T₁ group. There were no significant differences in EE and ash content as well as pH between the treatment groups. A typical temperature curve was found in T₁ during active composting phase but the temperature was more or less same in T₂ during the whole experimental period. From the experiment, it was found that crude fiber degradation rate is faster and CP content was higher in the T₂ compared to T₁ that might be indicated that vermicomposting is more beneficial than composting.

Keywords: vermicompost; compost; cattle manure; biological degradation; soil fertility

1. Introduction

Bangladesh belongs to 3rd largest livestock population in Asia and plays an important role in the economy of Bangladesh (Barman *et al.*, 2017; Baset *et al.*, 2003; Begam *et al.*, 2007; Rahman *et al.*, 1998, 1999 and 2002). It is estimated that approximately 156 million tons of cattle manure is produced every year in Bangladesh (Modak *et al.*, 2019) besides meat, milk and other by-products. These huge manures are a big issue of environmental pollution if not these treated properly. Animal wastes are the key elements for environmental pollution and therefore should be treated accordingly. Solid and liquid wastes release nitrate and phosphate to the soil and water streams, as well as carbon di oxide, methane, ammonia, hydrogen sulphide, di & tri methyl sulphide gases are released to the air during aerobic and anaerobic decomposition (Ahsan *et al.*, 2014; Lee *et al.*, 2009; Won *et al.*, 2016) due to inappropriate treatment of wastes (Ahsan *et al.*, 2013; Sarker *et al.*, 2009; Roy *et al.*, 2013). Cattle manure is a valuable resource as a soil fertilizer, as it provides high contents of macro and micro-nutrients for crop growth and is a low-cost alternative to mineral fertilizers (Ghos *et al.*, 2004; Islam *et al.*, 2010; Rahman *et al.*, 2008; Sarker *et al.*, 2018). Composting and vermicomposting are two well known processes for the utilization of manures that produced composts and vermicompost. Both compost and vermicompost are the rich source of organic matter for soil health and that are also excellent soil amendment

(Rahman *et al.*, 2020 and Rana *et al.*, 2020). Microorganisms as well as earthworm help to stabilize nutrients in the compost and vermicompost from waste materials and reduce the risk of environmental hazards.

Aerobic decomposition of organic substances occurred during composting process and detoxifies the toxic substances along with pathogens, insects, and larvae, weed seeds, etc. due to high temperature arisen from microbial activity. Composting process reduces the particle size of the organic matter (OM) and increases nutrient availability for plant. Enzymatic action of both mesophilic and thermophilic bacteria along with fungi help to decompose the OM that increases the temperature. When temperature starts to reduce after maximum OM break down, fungal growth occur that enhances maturation and humification at the curing or declining phase of composting. Prerequisites of composting are moisture content, turning and aeration, carbon nitrogen ratio (C/N) of the composting materials. Initial moisture should be 60-65% and the C/N ratio should be 25-30: 1 for the proper growth and development of the microorganisms. Turning ensures the O₂ level that also helps to maintain the normal physiology of the aerobic microorganisms (Lee *et al.*, 2009). On the advancement of the composting process, organic materials are degraded through a wide variety of biological and biochemical processes with microbial enzymes. Bulking materials such as saw dust, straw, crop residue and tree leaves may be added with composting materials to optimize the moisture and C/N (Rahman *et al.*, 2013; Alam *et al.*, 2013). Saw dust is a carbon rich bulking material that has a very fine particle carbon source (Won *et al.*, 2016). The ultimate goals of composting are to be the safe handling of organic wastes and enhancement of soil's fertility as well as crop productivity.

Vermicomposting is a process that involves the oxidation and stabilization of organic wastes through the joint action of earthworms and microorganisms (Punde and Ganorkar, 2012). Vermicomposting process turns the waste into a valuable soil amendment called vermicompost. This technique has been widely used to process many different types of residue, including organic and industrial wastes (Edwards *et al.*, 1998). Earthworms fragment the waste substrate and accelerate the rate of decomposition of the organic matter, leading to a composting effect through which unsterilized organic matter becomes stabilized (Hayawin *et al.*, 2010). Vermicomposting is also an aerobic process where O₂ is required for the survival of the earthworms. Limited amount of microorganisms also active in the vermicomposting process, where microbial enzymes enhance the OM degradation along with earthworms gut digestion. Vermicompost contains plant hormones like auxin and gibberellins and enzymes which believed to stimulate plant growth and discourage plant pathogens. Vermicompost contains a higher amount of NKP (nitrogen 2-3%, potassium 1.85- 2.25% and phosphorus 1.55-2.25%) than compost, micronutrients and beneficial soil microbes (Rahman *et al.*, 2020). Worm biomasses are the means of cash income and also used as protein supplementation for poultry and fish. Vermicompost improves soil structure, texture, aeration, and water-holding capacity and prevents soil from erosion. Vermicompost is reported to have greater market acceptance based on better appearance and higher nutrient content and microbial activity than compost (Tognetti *et al.*, 2005), although its price is triple that of compost. Ngo *et al.* (2011) showed better performance of vermicompost than compost produced from buffalo manure, stating that vermicompost had better C/N ratio and contained stronger modified lignin compared to regular compost. A few sporadic studies of composting and vermicomposting had done to recycle the waste biomasses, but comparative study of compost and vermicompost of cattle manure had not yet done in Bangladesh. Therefore, this experiment was carried out to compare the organic matter degradation pattern in cattle manure through composting and vermicomposting.

2. Materials and Methods

2.1. Experiment location and duration of study

Two different experiments such as composting and vermicomposting were conducted at the same time and same environmental condition. Both the experiments were done in the field laboratory of Department of Animal Science, Bangladesh Agricultural University, Mymensingh during the period from January 21st to 22nd March, 2018. Composting operation was done in the composting shed and the vermicomposting operation was done in the vermicomposting shed. The laboratory Analysis was carried out at laboratory in the Department of Animal Science, Bangladesh Agricultural University, Mymensingh.

2.2. Experimental design and sampling

There were two treatments in this experiment such as composting (T₁) and vermicomposting (T₂) with three replications. Three replications were taken in each treatment to minimize the experimental errors. Cattle manure was used both for composting and vermicomposting in this experiment. A total of three composting pits were used to prepare compost from cattle manure with saw dust and three pits (locally called chari) were used for

vermicomposting to fulfill the objectives of the study. The samples were collected both from composting and vermicomposting pits at 0, 20, 40 and 60 days for proximate analysis.

2.3. Preparation of compost pit and composting operation

Field Laboratory of Animal Science Department has nine concrete-made compost pits. Among them three pits were used for composting operation as T₁. The pits were well built with an altitude of 3 feet, length of 2 feet, and width of 1.5 feet providing with sufficient environment for composting. About 60 kg of cattle manure and necessary amounts of saw dust were mixed together that contains 60% moisture. After mixing, the said amount of compost mix was put in each composting pit. The ambient temperature was 22°C at the beginning of composting process. Periodic temperature of the composting pit was measured by a foot long clinical thermometer. Turning of composting materials was performed manually after every 10 days to maintain the oxygen level for microbial growth (Figure 1a).

2.4. Preparation of vermicompost pit and vermicomposting operation

A total of 3 concrete pits, locally called chari was used to prepare vermicompost (T₂). The chari/pits were semicircular in shape having a diameter of 0.5 meter and a height of 0.3 meter. Approximately 30 kg manure was put in each chari/pit and a total of 90 kg cowdung was needed for this vermicomposting operation. There is a rich breeding stock of red worms in the farm section of waste recycle and renewable energy laboratory of Department of Animal Science, BAU. Red worm was collected and stored in appropriate breeding condition previously before setting the vermicomposting operation. All 3 pits were cleaned and 30 kg raw cow dung was added in each chari. About 100 g red worm was put on the surface of each chari and then covered the chari with straw after disappearing the worms (Figure 1b). The initial ambient temperature was 25°C and the approximate moisture was 75% for easy movement of the worms.



Figure 1. a) Turning operation in composting b) addition of earthworm in vermicomposting pit c) finished vermicompost.

2.5. Sampling for laboratory analysis

After settle down both the experiment (composting and vermicomposting), Samples were collected after every 20 days to see the degradation pattern of organic matter. Final samples were collected after 60 days both from composting and vermicomposting (Figure 1c) pits. Samples were kept at the refrigerator at 4°C before analysis. These collected samples were subjected to proximate analysis to identify dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and Ash according to AOAC (2004) and the pH was determined using a laboratory PH-mV meter.

2.6. Statistical analysis

The experiment was designed as CRD and analysis of variance (ANOVA) was done by using Microsoft excel computer program and differences among the treatment means were determined by the two paired t test.

3. Results and Discussion

3.1. Composition of raw material

The proximate compositions of cow dung were analyzed before starting of the experiment both for composting and vermicomposting. The parameters analyzed were DM, CF, CP, Ash, pH and temperature. Before starting the experiment, the composition of cow dung was same but saw dust was mixed with the compost mix to standardize the moisture percentage at 65%. So, the composition of compost mix and vermicompost mix were

found different at the initial day. Average percentage of DM, CF, CP, EE, Ash, and pH were 20.99, 16.12, 2.67, 11.32, 1.26, 14.43, 16.26 and 8.31, respectively in T₁ and T₂. A comparative higher DM and CF were found in T₁ due to addition of saw dust with the cow dung. Other values were found very close in both the treatments T₁ and T₂ (Table 1).

Table 1. Proximate composition of raw material at the starting day.

Parameters	Per cent (Means ± SD)	
	Composting material (T ₁)	Vermicomposting material (T ₂)
DM	35.14 ± 0.13	25.01 ± 0.14
CF (DM basis)	25.95 ± 0.51	23.03 ± 0.83
CP (DM basis)	8.92 ± 0.48	9.04 ± 0.45
EE (DM basis)	2.01 ± 0.17	2.44 ± 0.07
Ash (DM basis)	2.59 ± 0.51	2.51 ± 0.45
pH	8.37 ± 0.25	8.48 ± 0.25

3.2. Dry matter changing pattern during composting and vermicomposting

Initial DM was higher in T₁ (35.14%) compared to T₂ (25.01%) due to addition of dry saw dust with the fresh cow dung during composting but T₂ had no saw dust. Amount of DM was gradually increased with the advancement of both composting and vermicomposting. At the end of the experiment, a comparatively higher DM was also found in T₁ (57.25) compared to T₂ (47.65 %) after 60 days of experiment (Table 2). The trend of increasing DM was more or less similar in both the treatments. In case of composting (T₁), significantly (0.01>P) higher DM was found than vermicomposting (T₂) throughout the whole experimental period. Dry matter content increased with the increase of composting period. Sherman (2005) and Lee *et al.* (2009) also stated that initially 65% moisture contents are essential for aerobic microbial growth. Adeley and Kitts (1983) were also observed that DM gradually increased with the advancement of the composting period. Turning operations were performed in every 10 days in T₁ helps to reduce the moisture; similarly earthworm movement in the vermicomposting pits also a cause of moisture loss in T₂. Earthworms can consume organic substances and moves through the pit might be the cause of moisture loss during vermicomposting (Rahman *et al.*, 2020).

Table 2. Periodic change in DM (%) of composting and vermicomposting.

Period (days)	T ₁ (Means± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	35.14 ± 0.13 ^a	25.01 ± 0.14 ^b	0.0016	**
20	41.53 ± 0.55 ^a	32.78 ± 0.57 ^b		
40	50.64 ± 0.60 ^a	41.72 ± 0.48 ^b		
60	57.25 ± 0.52 ^a	47.65 ± 0.59 ^b		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, ** means significant at 1% level of probability

3.3. CF changing pattern during composting and vermicomposting

At the beginning of the experiment CF content was higher in T₁ (25.95 %) compared to T₂ (23.03 %). It was found a much lower CF in T₂ (4.19%) than T₁ (6.87%) at the end of the experiment (Table 3). A significant difference (0.01>P) was found in CF degradation between composting and vermicomposting. Higher CF contents in T₁ might be due to addition of saw dust to standardize the moisture and C/N ratio for composting. The CF degradation rate was also higher in T₂ (82%) compared to T₁ (74%) during 60 days of experimental period. A comparative higher CF digestion was occurred in T₂ might be indicated that earthworm can efficiently degrade the CF compared to microbial CF degradation. The CF and other organic substances are digested by the digestive juice available in the earthworm's gut. The grinding effect of its gizzard and the effect of its gut muscle movement result in the formation of casts (Garg *et al.*, 2008). Rahman *et al.* (2020) stated that red worm consumed the cattle manure and digested 82% of its CF within 45 days vermicomposting period. Another investigation showed that only 33% of CF was digested by microbial enzymes during 45 days of composting cattle manure with saw dust (Rana *et al.* 2020). It might be indicated that microbial enzymes involve in CF digestion that reduced the CF content during aerobic composting process and the degradation rate is slower than the earthworm's digestion.

Table 3. Shows periodic change in CF of composting and vermicomposting.

Period (Days)	T ₁ (Means ± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	25.95 ± 0.51 ^a	23.03 ± 0.83 ^b	0.0014	**
20	19.20 ± 0.18 ^a	18.31 ± 0.15 ^b		
40	13.41 ± 0.06 ^a	11.21 ± 0.14 ^b		
60	6.87 ± 0.17 ^a	4.19 ± 0.29 ^b		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, ** means significant at 1% level of probability

3.4. CP changing pattern during composting and vermicomposting

At the 1st day of experiment, the mean crude protein content of both composting and vermicomposting were 8.92 and 9.02% respectively, but the percentage gradually decreased in T₁ and more or less stable in T₂ during 60 days period. The final CP contents were 5.51 and 8.42% in T₁ and T₂ respectively (Table 4). There was a significant difference (P>0.05) in CP content between composting and vermicomposting at the end of the experiment. About 38% CP was lost in T₁ during 60 days of composting but only 7% CP was lost from T₂ might be indicated that nitrogen conservation rate was higher in vermicomposting process compared to composting. Lee *et al.* (2009) stated that nitrogen loss occurred during composting due to gaseous loss as NH₃ but may also occurred as nitrogen gas and NO_x loss. Hansen *et al.* (1989) reported that the total N loss was 33% of the initial N during the composting of sewage and straw mixtures and it would be increased up to 50% of the initial N during the composting of poultry manure. Rahman *et al.* (2020) stated that earthworms can boost the nitrogen levels of the substrate during digestion in their gut adding their nitrogenous excretory products, mucus, body fluid, enzymes, and even through the decaying dead tissues of worms in vermicomposting subsystem that increased the N content in the final vermicompost. A higher N content was also found by Krishan *et al.* (2014), Tripathi and Bhardwaj (2004) and Sitaramlaxmi *et al.*, (2013) in the final vermicompost. Yadav and Garg (2013) reported that, the vermicomposting significantly increased nitrogen, phosphorous, and potassium contents of the finished product.

Table 4. Periodic change in CP of composting and vermicomposting.

Period (Days)	T ₁ (Means ± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	8.92 ± 0.48 ^b	9.04 ± 0.45 ^a	0.015	*
20	7.80 ± 0.41 ^b	8.57 ± 0.27 ^a		
40	6.14 ± 0.26 ^b	8.39 ± 0.11 ^a		
60	5.51 ± 0.16 ^b	8.42 ± 0.13 ^a		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, * means significant at 5% level of probability

3.5. EE changing pattern during composting and vermicomposting

Ether extract was analyzed both from T₁ and T₂ throughout the experimental period. The EE statuses of composting and vermicomposting materials are shown in Table 5. Total EE contents were slightly reduced from initial state in both the treatments but statistically there were no significant differences.

Table 5. Change in EE of composting and vermicomposting.

Period (days)	T ₁ (Means ± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	2.01± 0.17 ^a	2.44± 0.07 ^a	0.495	NS
20	1.49±0.10 ^a	1.48±0.067 ^a		
40	1.47±0.093 ^a	1.45±0.099 ^a		
60	1.43±0.079 ^a	1.41±0.052 ^a		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, NS means not significant

3.6. Changes in ash content during composting and vermicomposting

The study found a little decrease in ash content in both the treatments over 60 days of experimental period, but the change did not vary significantly between T₁ and T₂ (Table 6). The ash analysis data are shown in Table 6. Jacob *et al.* (1997) observed that the ash content decreased with the advancement composting period. Rahman *et al.* (2020) conducted a vermicomposting experiment with red worm and found that ash content was slightly reduced from initial condition. Fornes *et al.* (2012) studied the nutrient stability during vermicomposting period and stated that mineral markedly decreased at the beginning of the treatment, phosphorus increased at the final stage, potassium and sulphur also decreased. They also showed that calcium, magnesium and sodium contents decreased on the advancement of vermicomposting period.

Table 6. Periodic change in ash content during composting and vermicomposting.

Period (Days)	T ₁ (Means ± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	2.59± 0.51 ^a	2.51± 0.45 ^a	0.447	NS
20	2.33±0.24 ^a	2.31±0.23 ^a		
40	2.32±0.19 ^a	2.17±0.21 ^a		
60	2.21±0.15 ^a	2.01±0.12 ^a		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, NS means not significant

3.7. pH changing pattern during composting and vermicomposting

It was found that pH were more than 8 in both the treatments throughout the experimental period except in 40th days (Table 7). The highest pH was observed at 20th days at both the treatments and the values were 8.54 and 8.61 in T₁ and T₂ respectively. Final pH was little lower compared to initial and 20th days in T₁ (8.06) and T₂ (8.17), but there were no significant differences in pH between the treatments. The reduction in pH in the final compost might be due to the production of CO₂ and organic acids by microbial activity during the process of biodegradation of manure (Haimi and Huhta, 1986). Factors affecting pH could be the initial decarboxylation of organic acids, the formation of ammonium from protein degradation, the mineralization of nitrogen followed by nitrification (NH₄ is transformed into NO₃) and the production of humic acids (Dias *et al.*, 2010; Sanchez-Monedero *et al.*, 2001). Nath *et al.* (2009) also reported that vermicomposting results in significant decreased in pH, total organic carbon and electrical conductivity.

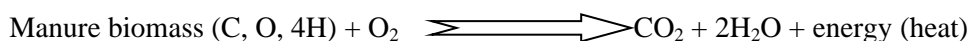
Table 7. Periodic change in pH during composting and vermicomposting.

Period (Days)	T ₁ (Means ± SD)	T ₂ (Means ± SD)	P value	Level of Significance
0	8.37± 0.25 ^a	8.48± 0.25 ^a	0.430	NS
20	8.54±0.12 ^a	8.61±0.11 ^a		
40	7.71±0.14 ^a	7.91±0.34 ^a		
60	8.06±0.19 ^a	8.17±0.16 ^a		

T₁= Composting, T₂ =Vermicomposting, Figures followed by same letter (s) within a row do not differ statistically, NS means not significant

3.8. Changes of temperature during composting and vermicomposting

When the manure was set for composting and vermicomposting, the initial temperature of both the treatments was 25°C, just like ambient temperature. The highest temperature was found in T₁ (60 °C) at 20th days and then gradually decreased (Figure 2). In case of T₂, temperature was more or same at the whole experimental period. After 60 days of experimental period, T₂ showed the equal of ambient temperature (26 °C), but T₁ showed a little higher temperature (30 °C). Troy *et al.* (2012) stated that a quick increase of temperature due to the production of heat and the rapid breakdown of easily degradable organic matter during active composting phase through microbial activity. Heat generation in the composting pile can be expressed with the following formula:



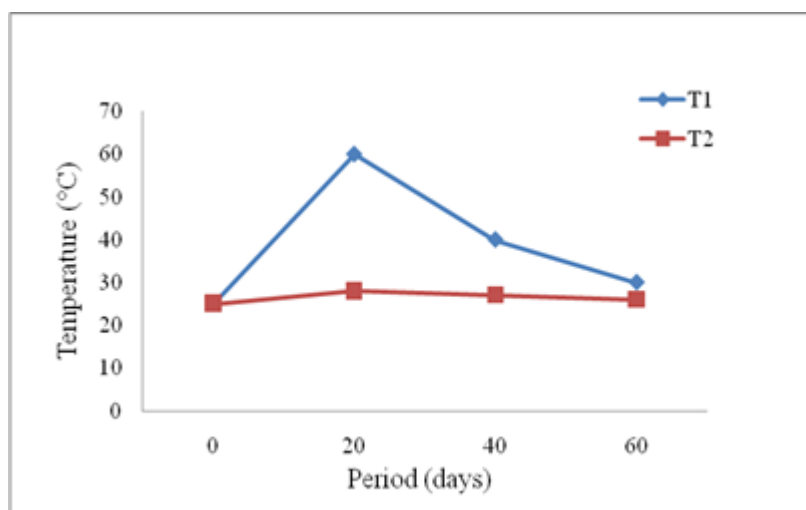


Figure 2. Periodic change of temperature.

4. Conclusions

From the above discussion, it can be concluded that organic matter (CF) degradation rate is faster in vermicomposting than that in composting for cattle manure. Crude protein or N content also higher the final vermicompost compared to compost. Ash and pH was more or less similar in both the treatments. Therefore, it might be concluded that vermicomposting of cattle manure is more effective compared to composting in terms of CF degradation and nutrient content.

Conflict of interest

None to declare.

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