Organic Matter Transformation during Rotary Drum Composting

Ajay S. Kalamdhad1* • Muntjeer Ali2 • Meena Khwairakpam2 • A. A. Kazmi2

ABSTRACT

Organic matter transformation using chemical and spectroscopic methods was studied for composting of four carbon/nitrogen (C/N) ratio waste combinations (C/N 16, C/N 22, C/N 30 and C/N 38) of grass cuttings, mix vegetable waste, cattle manure, food waste and sawdust. Temperature, moisture content, ash content, total organic matter, C/N ratio and water-soluble organic carbon (WSOC) concentrations were observed in a rotary drum composter for 20 days. In addition, a spectroscopic method (Fourier-transform infrared) was used to study the chemical composition of the organic matter. Temperature reached above 50°C in all waste combinations indicating the immense oxidation within the rotary drum composter, resulting in a final higher ash content (62.28%) in C/N 16 compared to about 30-32% for C/N 22, 30 and 38. The C/N ratio decreased rapidly from initial values of 16, 22, 30 and 38 to 5.4, 10.9, 16.6 and 27.2 after 20 days of composting. Total organic carbon (TOC) of the compost displayed a similar trend to WSOC, which decreased to around 34, 31 and 18% in C/N 22, 30 and 38 compared to 58% in C/N 16. The infrared spectra of all treatments exhibited the same band pattern, indicating unnoticeable qualitative changes during the composting process. The decrease of the 2930/1030, 2850/1030 (aliphatic C/aromatic C) and 2930/1630 (aliphatic C/polysaccharide) ratios monitored in all treatments (higher decrease in C/N 16) and an increase of the 1380/2930 ratio indicated progress of the composting process and consequently a higher degree of decomposition.

Keywords: C/N ratio, Fourier transform infrared spectroscopy, organic matter, rotary drum, water-soluble organic carbon

INTRODUCTION

The use of compost in agriculture as soil amendment is one of the practices for the sustainable management of soils that also contributes to the recycling of organic residues. Composting of biological material generally means a full or a partial mineralization of organic compounds by producing CO₂, H₂O, NH₃, or NO₃, sulphates and carbonates of Ca, Mg and K, oxides of Fe and Mn, and phosphates. Some of these mineralization products get lost from the composting biomass as gaseous compounds (CO₂, H₂O, NH₃), some as solutes with the drainage water (NO₃⁻, SO₄²⁻, K and Mg hydrogen-carbonates) and some remain as precipitated or adsorbed compounds (NH₄⁺, K⁺, Ca²⁺, Mg²⁺, phosphates, sesquioxides) in the final compost product (Saad 2001). A small metabolic sidestep of all composting processes, even under strongly oxidative conditions, leads to the decay of biological masses to form fulvic and humic substances (Saad 2001). These are able either to mummify decaying organic tissues or to become strongly precipitated as humates on the surface of clay particles (mulm-fall). In both cases these relatively stable or even inert by-products create the dark, blackish grey color of all composts.

Approximately 50% of added organic matter becomes fully mineralized, mostly due to the degradation of easily degradable compounds such as proteins, cellulose and hemicellulose, which are utilized by microorganisms as C and N sources. The residual organic matter contains newly formed macromolecules along with non-degradable organic matter jointly forming humic-like substances, the most stable fraction of mature compost (Chefetz et al. 1996). Organic matter is decomposed for the most part of the soil micro-flora, although slight decomposition occurs even under biotic or photochemical conditions (Saad 2001). In aerobic conditions, there is a great diversity of decomposers, consisting of fungi, actinomycetes and a wide range of bacteria, which degrade the readily available organic components or transform them into stable humic components (Garcia et al. 1992; Diaz-Burgoa et al. 1994; Amir et al. 2004). It is reasonable to expect that the humification and transformation process might differ depending upon raw materials used for composting (Huang et al. 2006). Humic substances constitute the most important fraction of organic matter because of their effect on soil ecology, structure, fertility and plant growth. Many tests have been proposed to assess the biodegradation and humification of organic matter resulting in compost maturity and stability. Changes in compost stability or the degree to which the composts have been decomposed, can be predicted with C/N in the solid phase (Jiménez and García 1992), soluble organic carbon content in water extract (Garcia et al. 1991; Inbar et al. 1993), humification indices (Jiménez and García 1992; Chefetz et al. 1996), oxygen and CO₂ respirometry (Iannotti et al. 1994), plant growth bioassay, or NMR and IR spectroscopy (Chen and Inbar 1993). Several studies have investigated organic matter transformation during composting of municipal solid waste, municipal sewage sludge and separated cattle manure using chemical, spectroscopic and microbiological methods (Chefetz et al. 1981; Chen and Inbar 1993; Iannotti et al. 1994; Hsu and Lo 1999; Adani et al. 2001; Gea et al. 2004; Jouraiphy et al. 2005; Huang et al. 2006).

The above-mentioned investigations generally dealt with windrows and static piles types of composting for various kinds of wastes. However, information on transformation of organic matter in high rate composting such as a rotary drum for mixed organic wastes is rather limited. A rotary drum provides agitation, aeration and mixing of the compost, to produce a consistent and uniform end product. In warm, moist environments with ample amount of oxygen and organic material available, aerobic microbes flourish and decompose the waste at a quicker pace. The compos-
Rotary drum composting

MATERIALS AND METHODS

C/N 16, C/N 22, C/N 30 and C/N 38 for 20 days. The objective of this work was to study organic matter transformation during rotary drum composting of different waste combinations. Therefore, the focus was to study organic matter transformation during rotary drum composting of different waste combinations of C/N 16, C/N 22, C/N 30 and C/N 38 for 20 days.

MATERIALS AND METHODS

Rotary drum composting

In order to study compost stability, a rotary drum composter of 250 L capacity was used. The main unit of the composter, i.e. the drum, is 0.92 m in length and 0.9 m in diameter, made up of a 4 mm thick metal sheet. The inner side of the drum is covered by anti-corrosive coating. The drum is mounted on four rubber rollers attached to a metal stand and the drum is rotated manually. In order to provide the appropriate mixing of wastes, 40 mm angles are welded longitudinally inside the drum. In addition to that, two adjacent holes are made on the bottom of the drum to drain off excess water. The shredded mixed organic waste is loaded into the drum by means of a plastic container and filled up to 70% of the total volume. Aerobic conditions are maintained by opening up both half side doors of the drum after four rotations are provided manually on a daily basis, which ensure proper mixing and aeration.

Cattle (buffalo) manure (C/N=20), mixed green vegetable (uncooked cabbage, spinach, cauliflower, potato, bottle gourd, raddish, etc.) waste (C/N=18), food waste (cooked) (C/N=16), grass (Japanese carpet) cuttings (C/N=15) and sawdust (teak, aini, banyan, bijasal, etc.) (C/N=540) were derived from various places of Roorkhee City, India. Prior to composting, the maximum particle size in the mixed waste was restricted to 1 cm in order to provide better aeration and moisture control. The material is rendered more susceptible to bacterial invasion by exposing a greater surface to attack and destroy the natural resistance of vegetation to microbial invasion (Gotaas 1956). The compost was prepared with four different proportions of MSW composition, as detailed in Table 1. About 100 g of each grab samples were collected from six different locations, mostly at the mid span and ends of the composter by a compost sampler without disturbing the adjacent materials. Finally all the grab samples were mixed together and considered as a homogenized sample. Triplicate samples were collected and stored at 4°C immediately for analysis. Temperature was monitored using a digital thermometer throughout the composting period. Sub-samples were air dried, ground to pass 0.2-mm sieve and stored for further analysis.

Physico-chemical analysis

The moisture content of composts was determined after drying to a constant weight at 105°C in a forced-air oven (TempStar, India). Total nitrogen was analyzed by the Kjeldahl method and total organic carbon (TOC) using a Shimadzu (TOC-V CSM) Solid Sample Module (SSM-5000A), respectively on sub-samples of composts. Ash measurements were determined at 650°C for 2 h in a muffle furnace. Decomposition was calculated from the initial (A0) and final (A2) ash content and initial TOC (in fractions) according to the equation (Jouraiphy et al. 2005):

\[ \frac{((A_2 - A_0)/A_0) \times (100 - C_i) \times 100}{100} \]

Water-soluble organic carbon (WSOC)

Ten grams of each compost sub-sample was weighed into a 250 ml polycarbonate centrifuge tube and extracted with 100 ml of deionized water by shaking for 24 h. The extracts were centrifuged at 8000 rpm for 20 min and filtered through 0.45 μm filter membranes (Pall Corporation, India). Water extracts were stored at 4°C until analysis for water-soluble organic carbon using a Shimadzu TOC-5000A (Huang et al. 2006).

Fourier-transform infrared (FTIR) spectroscopy

FTIR spectra were obtained for a wave number range of 400-4000 cm⁻¹ on a Perkin Elmer GX FT-IR system equipped with OMNIC software. The samples were prepared for analysis by mixing 1 g of dried KBr with approximately 7-10 mg of sub-sample and compressing the mixture to pellets using a hydraulic press.

Statistical analysis

Repeated measures treated with ANOVA were used to analyze the significant difference between different waste combinations of C/N 16, C/N 22, C/N 30 and C/N 38 for observed parameters using Statistica software. Tukey’s t-test was also performed to identify the homogeneous type of waste combinations for their different chemical properties i.e. moisture content, ash content, C/N ratio, decomposition, etc. The probability levels used for statistical significance were P < 0.05 for the tests.

RESULTS AND DISCUSSION

The composting process

The mesophilic, thermophilic, cooling and curing stages are clearly depicted in all treatments (Fig. 1). C/N 16 con-

Table 1 Waste proportion (wt. (%) basis).

<table>
<thead>
<tr>
<th>Feedstock material (MSW composition)</th>
<th>C/N 16</th>
<th>C/N 22</th>
<th>C/N 30</th>
<th>C/N 38</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle manure (kg)</td>
<td>5</td>
<td>10</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Grass cuttings (kg)</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Food waste (cooked) (kg)</td>
<td>16</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Vegetable waste (uncooked) (kg)</td>
<td>30</td>
<td>20</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Saw dust (kg)</td>
<td>0</td>
<td>2.7</td>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td>Compost (kg)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total weight of mixture (kg)</td>
<td>63</td>
<td>55.7</td>
<td>61.5</td>
<td>62</td>
</tr>
<tr>
<td>Initial C/N ratio</td>
<td>16</td>
<td>22</td>
<td>30</td>
<td>38</td>
</tr>
<tr>
<td>Initial Moisture content (%)</td>
<td>72.3 ± 1.2</td>
<td>69 ± 1.5</td>
<td>68.7 ± 0.8</td>
<td>67.7 ± 1.3</td>
</tr>
<tr>
<td>Initial ash content (%)</td>
<td>48.5 ± 1.3</td>
<td>53 ± 1.1</td>
<td>49.1 ± 1.3</td>
<td>41.8 ± 0.9</td>
</tr>
<tr>
<td>Initial total organic carbon (%)</td>
<td>29.8 ± 0.8</td>
<td>35.2 ± 0.9</td>
<td>41.2 ± 1.3</td>
<td>46.5 ± 1.2</td>
</tr>
<tr>
<td>Initial total nitrogen (%)</td>
<td>1.9 ± 0.2</td>
<td>1.5 ± 0.3</td>
<td>1.3 ± 0.2</td>
<td>1.2 ± 0.1</td>
</tr>
</tbody>
</table>
taining a high amount of grass cutting reached 59°C (maximum in all 4 cases) and entered the thermophilic phase after two days from the beginning of the treatment. This temperature rise resulted from intense microbial activity favored by the high concentration of easily decomposable organic molecules (Tourphy et al. 2005). The longer thermophilic phase (5 days) as well as the higher rise in temperature at the beginning of composting was attributed to a sufficient supply of carbon source. Further, a cooling period was observed until the 6th day, which increased up to 55.2°C and entered the thermophilic phase (5 days) as well as the higher rise in temperature. The temperature rise resulted from intense microbial activity starting at the beginning of the treatment. This temperature rise varied significantly among all four treatments (P < 0.05).

Moisture loss during the composting process can be viewed as an index of decomposition rate, since the heat generation which accompanies decomposition drives vaporization (Liao 1996). However, the composting material should have a certain moisture content in it for the organism to survive. C/N 16 observed a higher initial moisture content (72.3%) due to the higher content of grass cutting and food waste, which further dropped to 61.7%. Only 14.7% moisture loss was observed since it containing more food/vegetable waste, while in C/N 22, moisture content at the beginning was 69.1% which reduced to 48.5% within 20 days (Table 2). At the beginning moisture content in C/N 22 was 68.5, 67.7%, which reduced further up to 53.5 and 50.1% in C/N 30 and 38, respectively. The difference in moisture content in the top and bottom portions of the compost in all cases was around 2-4%, implying uniformity achieved by rotation. Leachate formation was not observed during the composting period. Lower moisture loss (14.7%) was observed in C/N 16 compared to 29.6, 22.1 and 26.1% in C/N 22, 30 and 38, respectively. On analyzing the results by ANOVA, moisture content varied significantly among all four treatments (P < 0.05). Results point out that lower final moisture content observed in C/N 22 (48.5%) indicates lower microbial activities (Gomez et al. 2006).

The ash content increased with composting time with 62.2, 30.2, 31.7 and 24.4% for C/N 16, 22, 30 and 38, respectively, owing to the loss of organic matter through microbial degradation (Table 2). The variation in the ash content among all four treatments varied significantly (P = 0.001). The decrease in organic matter synthesized with an increase in the mass ash of treatments. Decomposition was about 45% in C/N 16, which contained a higher amount of grass cuttings than 31, 35 and 32% in C/N 22, 30 and 38, respectively (Table 3), which indicated that intensive decomposition had taken place during C/N 16. On analyzing the results by ANOVA, decomposition varied significantly among all four treatments (P < 0.05).

The change in the C/N ratios reflects the organic matter decomposition and stabilization achieved during composting. The decomposition of organic matter is brought about by living organisms, which utilize carbon as a source of energy and nitrogen for building cell structures. The C/N ratio decreased rapidly from initial values of 16, 22, 30 and 38 to 5.4, 10.9, 16.6 and 27.2 after 20 days of composting (Table 3). Changes in the C/N ratio among all four treatments varied significantly (P < 0.05). If the C/N ratio of compost is more, then excess carbon tends to utilize nitrogen in the soil to build cell protoplasm. This results in a loss of soil nitrogen and is known as ‘robbing of nitrogen in

Table 2 Changes in moisture content and ash content during composting.

<table>
<thead>
<tr>
<th>Days</th>
<th>Moisture content (%)</th>
<th>Ash content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>72.3 ± 1.2 a</td>
<td>69.1 ± 1.3 a</td>
</tr>
<tr>
<td>3</td>
<td>72.1 ± 1.7 a</td>
<td>65.7 ± 2.1 a</td>
</tr>
<tr>
<td>5</td>
<td>68.4 ± 1.1 b</td>
<td>64.4 ± 1.5 b</td>
</tr>
<tr>
<td>8</td>
<td>65.5 ± 1.5 b</td>
<td>61.9 ± 1.8 b</td>
</tr>
<tr>
<td>10</td>
<td>64.3 ± 0.8 cd</td>
<td>59.4 ± 0.8 cd</td>
</tr>
<tr>
<td>12</td>
<td>63.1 ± 0.9 cd</td>
<td>57.3 ± 0.8 e</td>
</tr>
<tr>
<td>15</td>
<td>62.9 ± 1.2 cd</td>
<td>51.8 ± 1.1 e</td>
</tr>
<tr>
<td>20</td>
<td>61.7 ± 1.1 d</td>
<td>48.5 ± 1.5 c</td>
</tr>
</tbody>
</table>

Table 3 Changes in C/N ratio and decomposition during composting.

<table>
<thead>
<tr>
<th>Days</th>
<th>C/N ratio</th>
<th>Decomposition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.9 ± 0.2 a</td>
<td>22.1 ± 0.3 a</td>
</tr>
<tr>
<td>3</td>
<td>11.3 ± 0.4 b</td>
<td>22.7 ± 0.2 b</td>
</tr>
<tr>
<td>5</td>
<td>11.2 ± 0.3 b</td>
<td>18.4 ± 0.4 c</td>
</tr>
<tr>
<td>8</td>
<td>9.3 ± 0.5 c</td>
<td>20.7 ± 0.3 d</td>
</tr>
<tr>
<td>10</td>
<td>12.2 ± 0.4 b</td>
<td>19.7 ± 0.2 e</td>
</tr>
<tr>
<td>12</td>
<td>9.1 ± 0.3 c</td>
<td>16.3 ± 1.0 f</td>
</tr>
<tr>
<td>15</td>
<td>7.7 ± 0.2 c</td>
<td>13.8 ± 0.4 g</td>
</tr>
<tr>
<td>17</td>
<td>6.6 ± 0.3 c</td>
<td>12.6 ± 0.2 h</td>
</tr>
<tr>
<td>20</td>
<td>5.3 ± 0.2 c</td>
<td>10.9 ± 0.4 i</td>
</tr>
</tbody>
</table>
the soil’ (Gotaas 1956). If, on the other hand, the C/N ratio is too low the resultant product does not help improve the structure of the soil. It is hence desirable to control the process so that the final C/N ratio is ≤20 (Hirai et al. 1983; CPHEEO 2000). Therefore, it can be concluded that compost with an initial C/N ratio of 30 reached maturation after 20 days of composting, similarly as Huang et al. (2004, 2006).

**Water-soluble organic carbon (WSOC)**

The alkaline pH of the water extracts throughout the composting process was probably due to the release of NH3 from the composts. WSOC is the most readily active biological parameter in compost, since organic carbon in the water extracts of immature compost consists of sugars, hemi-cellulose, phenolic substances, amino acids, peptides and other easily biodegradable substances (Hsu and Lo 1999). The WSOC contents of C/N ratios 16, 22, 30 and 38 gradually decreased from initial values of 3144, 2740, 2684 and 2608 mg/kg to 611, 378, 501 and 520 mg/kg, respectively (Fig. 2). On analyzing the results by ANOVA, WSOC varied significantly among all four treatments during 20 days of the composting period ($P < 0.05$). The largest decrease in WSOC content (79%) was observed for C/N 22 after one week of composting. C/N 16 and C/N 30 also observed a significant decrease (67%) after one week of composting. The least decrease (62%) was observed for C/N 30 during the first initial week, but a continuous decrease was observed until the 20 days of the composting period. The decrease in WSOC contents was very low after 12 days of composting in all cases, indicating the stability of finished compost. Final results indicated a 80, 86, 81 and 80% decrease in WSOC contents achieved in C/N 16, 22, 30 and 38, respectively in the rotary drum compostor. A continuous decline in WSOC was reported earlier by Inbar et al. (1993) and Leita and De Nobili (1991) for cattle manure and municipal solid waste (MSW), respectively.

However, others have reported that there is an initial increase followed by a gradual decrease in WSOC during composting (Dudley et al. 1986; Iannotti et al. 1994; Hsu and Lo 1999). TOC of the compost displayed a similar trend to WSOC. An exponential model shows a strong correlation with an $R^2$ value of 0.85, 0.88, 0.87 and 0.94 between TOC and WSOC, respectively in C/N 16, 22, 30 and 38. TOC decreased rapidly from 30, 35.3, 41.2 and 46.5% to 12.3, 23.2, 28.5 and 38.3% after a 20-day composting period respectively in C/N 16, 22, 30 and 38. Around 34, 31 and 18% of the TOC in C/N 22, 30 and 38 were utilized by microorganisms as a source of energy compare to 58% in C/N 16. On analyzing the results by ANOVA, TOC varied significantly among all four treatments ($P < 0.05$). The main components of the WSOC in immature composts are sugars, hemicellulose, phenolic substances, organic and amino acids, peptides, and other easily biodegradable substances (Chen and Inbar 1993; García et al. 1991). Humic substances that are resistant to further decomposition are the major components of SOC in mature compost. A decline in WSOC is one of the indicators of compost maturity (Garcia et al. 1991; Inbar et al. 1991; Saviozzi et al. 1992). Results indicated that more degradation of organic matter took place in C/N 16 and 22 compared to C/N 30 and 38 within the 20-day composting period, indicating that the type of raw material greatly affect the WSOC content during composting (Hsu and Lo 1999).

**Infrared spectroscopy (FTIR)**

The FTIR spectra of the compost at the different stages (1, 7, 15 and 20 days) of treatments (C/N ratios) show similar areas of absorbance and different intensity of certain bands (Fig. 3). The main absorbance bands in all treatment spectra were: a very large broad band centered on 3400 cm$^{-1}$ due to the hydrogen vibrations of alcoholic OH, phenol or carboxyl groups (COOH), but also to N–H vibrations of amides, two distinct peaks at 2930 and 2850 cm$^{-1}$ (C-H asymmetric,
C-H stretch of –CH aliphatic), a peak at 2365 cm\(^{-1}\) due to stretching of CO\(_2\), a well-pronounced peak at 1630-1660 cm\(^{-1}\) (C=C in aromatic structure, COO\(^{-}\) and C=O of amides, ketones and/or quinines), a small peak at 1560 cm\(^{-1}\) (amide II bonds), the band at 1420–1430 cm\(^{-1}\) is caused by the absorbance of several aliphatic structures, phenolic OH groups, COO\(^{-}\) groups, stretch vibrations of aromatic rings and carbonates, peaks at 1510, 1462, 1454 and 1420 cm\(^{-1}\) are typically assigned to aromatic rings of lignin, a small peak at 1380 cm\(^{-1}\) assigned to ammonium carbonate formed by reaction of ammonia and CO\(_2\), a broad peak at 1030 cm\(^{-1}\) assigned to C-O stretch of polysaccharide, Si-O asymmetric stretch of silicate impurities. The observed results are supported by other researchers (Chen and Inbar 1993; Hsu and Lo 1999; Baddi et al. 2004; Castaldi et al. 2005; Jouraiphy et al. 2005; Huang et al. 2006; Grube et al. 2006). The above absorbance bands were observed in all C/N ratios but few peaks were observed in only one or two C/N ratios such as a weak band at 1265-1223 cm\(^{-1}\) in C/N 16 and 38 due to amide III or aromatic ethers.

The IR spectra of all treatments exhibited the same band pattern, indicating that no noticeable qualitative changes occurred during the composting process. Changes during composting affected only band intensities, indicating that the increase in composting time does not involve significance changes in the compost composition. In particular, a drop occurred in the abundance of structures absorbed in the aliphatic region at around 2930 and 2850 cm\(^{-1}\) in all C/N ratios especially in C/N 16. A significant increase in the height of the peak at 1630-1660 cm\(^{-1}\) occurred in C/N 16 and 22 but a small drop was observed in C/N 30 and 38. Conversely, a small rise in the abundance of structures which absorb at around 1034 cm\(^{-1}\) occurred in only C/N 22 other than a significant drop observed in C/N 16, 30 and 38. This can be explained with the use of aliphatic and peptide structures and carbohydrates such as polysaccharides, cellulose and hemicellulose by the microbes, to meet their energy needs (Jouraiphy et al. 2005, 2008).

Quantitative evaluation of the composting process and maturity is based on the comparison of relative intensity ratios of selected absorbance bands. Smidt and Lechner (2002) and Grube et al. (2006) showed similar results in which a decrease of the 2930/1030, 2850/1030 (aliphatic C/aromatic C) and 2930/1630 (aliphatic C/polysaccharide) ratios monitored in all treatments (higher decrease in C/N 16) and an increase of the 1380/2930 ratio indicated progress of the composting process and consequently a higher degree of decomposition. This is in agreement with the studies of the whole compost FTIR spectra carried out by Hsu and Lo (1999), who also showed that easily biodegradable
organic matter components, such as aliphatic chains, polysaccharides, alcohols and proteins are decomposed and therefore, mature compost contained more aromatic structures of higher stability.

**CONCLUSIONS**

Organic matter transformation was studied by analyzing changes in WSOC, TOC and IR spectra for different waste composition in a rotary drum. The largest decrease in WSOC and TOC was observed for a lower initial C/N ratio waste composition i.e. C/N 16. The decomposition was 45% for C/N 16 compared to 31, 35 and 32% for C/N 22, 30 and 38, respectively. Similarly, for C/N 16, the IR spectra revealed the largest drop in the aliphatic region around 2930 and 2850 cm⁻¹. In addition, a greater decrease of the 2930/1030, 2850/1030 (aliphatic C/aromatic C) and 2930/1630 (aliphatic C/polysaccharide) ratios and an increase of the 1380/2930 ratio was observed indicating higher stability. The IR spectra of all treatments exhibited the same band pattern, indicated that no noticeable qualitative changes occurred during the composting process. FTIR spectra indicated that easily biodegradable organic matter components, such as aliphatic chains, polysaccharides, alcohols and proteins are decomposed and therefore, the mature compost contained more aromatic structures of higher stability. Therefore, it can be insinuated that rotary drum composting is more efficient for composting of various kinds of waste at lower initial C/N ratios i.e. C/N 16.

**ACKNOWLEDGEMENTS**

The authors gratefully acknowledge the financial support of the Department of Science and Technology (DST), Government of India.

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