

## Evaluation of Organic Matter Stability in Wood Compost by Chemical and Thermogravimetric Analysis

Nada, W. M.<sup>1</sup>, Van Rensburg, L.<sup>3</sup>, Claassens, S.<sup>3\*</sup>, Blumenstein, O.<sup>1</sup> and Friedrich, A.<sup>2</sup>

<sup>1</sup>Institute of Earth and Environmental Sciences, North-West University, Potchefstroom 2520, South Africa

<sup>2</sup>Potsdam University, Karl-Liebknecht Strasse 24-25, 14476 Potsdam, Germany

<sup>3</sup>School of Environmental Sciences and Development, North-West University, Private Bag X6001, Potchefstroom 2520, South Africa

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**ABSTRACT:** This study investigated maturation and stability levels during composting of *Quercus robur* (QR) woodchips mixed with different nitrogen sources (horse manure, HM and lake mud, LM) for potential agronomic utilisation. The woodchips were mixed with HM and LM, respectively, at mixing ratios of 1QR:2HM or 1QR:2LM. The experiment was conducted in a greenhouse over 100 days. During composting, organic carbon and its fractioning and humification constituents were quantified. In the final compost product, pH, organic matter (OM), cation exchange capacity (CEC) and selected available nutrients were measured. Thermostability of compost, compared with that of soil and compost mixed with charcoal were also quantified. Results showed OM evolution during the composting process with total organic and extractable carbons and humification indices decreasing, while the degree of humification increased. Compost produced from the 1QR:2HM mix resulted in the highest available nutrients, CEC and OM content values in the final product. Thermogravimetric profiles indicated that compost OM thermostability was higher than that in soil and higher for the 1QR:2HM than the 1QR:2LM mix. Application of charcoal revealed no additional stabilising effect of OM in wood compost.

**Key words:** Earthworms, Humification, Maturity, Vermicompost, Woodchips

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### INTRODUCTION

Organic wastes, such as wood, pulp and paper, or any cellulose, produce massive quantities of waste materials. Environmentally responsible management and/or disposal of these organic wastes have become a serious global challenge. Traditionally, wood wastes have been disposed of by burning in the field. However, it would be more environmentally responsible to dispose of wood without combustion to avoid the release of carbon dioxide (CO<sub>2</sub>), one of the critical greenhouse gases. Therefore, instead of burning as a management option, the current investigation focused on the development of eco-friendly technologies to manage wood waste resources. One potential solution to this challenge is to produce compost from the wood waste.

Composting of organic wastes is a well established method to obtain chemical stabilisation, biological maturation and sanitisation of the wastes before application to soil. It consists of a managed biological

transformation of organic matter (OM) by aerobic microorganisms which leads to extended mineralisation to CO<sub>2</sub>, ammonia and water, so that the end-product is relatively stable, reduced in quantity compared to the initial amount of waste, and free from disturbing odours, pathogens and seeds (McClintock, 2004). In the same context, compost can be produced by using earthworms, a process known as vermicomposting. Vermicomposting involves the addition of certain species of epigeic earthworms to enhance the conversion of organic wastes and is generally more efficient than composting because earthworms ingest OM and create conditions that favour the colonisation and degradation of partially-decomposed and fragmented organic material by aerobic microorganisms (Edwards, 2004). During vermicomposting, mineralisation of organic wastes occurs due to the combined action of microorganisms and earthworms (Nogales *et al.*, 2008). Some species of epigeic earthworms can live in decaying organic

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\*Corresponding author E-mail: sarina.claassens@nwu.ac.za

waste materials and convert it to odour free, fine particulate materials high in available nutrients (Suthar, 2007).

It should, however, be realised that the utilisation of wood compost in soils requires the development of appropriate techniques for final characterisation of organic fertilisers. Such techniques would allow assessing the level of stabilisation and maturity, in order to improve agronomic performance and reduce possible negative environmental impacts. The study of the humification processes taking place during composting has been an important research topic and the interest in these humification processes is twofold. First, the OM humification during composting has been considered as a suitable index for assessing compost stability and second, the agricultural value of the final compost increases when the OM reaches a high level of humification, especially when composts are used as a source of soil organic matter (Wu & Ma, 2002). Organic matter humification is usually studied in order to understand the transformations undergone by both the whole organic matter (Itavaara *et al.*, 2002) and the humic fractions extracted from the composts (Veeken *et al.*, 2000).

The stabilisation indices of OM caused by humification processes are usually based on the ratios between different alkali extractable fractions of the OM such as humic acids, fulvic acids, total extractable carbon (TEC), etc (Tittarelli *et al.*, 2002). The addition of compost with a greater component of humified organic matter leads to longer lasting effects of this OM in the soil, increasing the agricultural value of the composts. On the other hand, application of non-stabilised organic materials could negatively affect both crops and the environment because of the presence of phytotoxic compounds (Butler *et al.*, 2001). Nevertheless, the humic substances formed during composting processes are called humic-like substances as they are not expected to have the same properties as those extracted from soils or from more humified materials, like coals or peats, where the humification process takes place over a considerably longer time scale than in the composting pile. Ample evidence exists in the literature that composting of organic materials causes a decrease of total organic carbon (TOC) and TEC contents and an increase in the ratios of TEC/TOC, humic acid (HA)/TOC, HA/TEC and HA/fulvic acid (FA) in bulk substrates (Vargas-García *et al.*, 2006).

Another aspect that needs to be addressed is how to increase the degree of OM stability in compost, which will be reflected by its sustained presence in the soil. Physical techniques such as thermogravimetric analysis (TGA) have been applied to assess compost

biostabilisation. For this technique a small sample is sufficient, it does not require chemical extraction and is easy to reproduce (Dell'Abate *et al.*, 2000; Mondini *et al.*, 2003). From a statistical point of view, chemical methods are effective only in distinguishing among different drying methods connected with manure management systems. Only TGA can identify mature samples by means of total mass loss in the range RT (room temperature) – 800°C, mass loss in the range 350 – 425°C and energy release at 500°C. In addition, thermogravimetric profiles could be used to define a fingerprint for this kind of biomass (Dall'Ara *et al.*, 2008).

Fewer studies are available on methods to assess wood compost stabilisation or maturity, particularly of wood vermicompost which has not undergone "conventional" composting processes. Therefore, the aim of this work was to evaluate the OM stability during composting of woodchips mixed with HM and LM, respectively, by means of the assessment of humification parameters and thermal analysis. During composting, the wood compost was examined in terms of its changes in organic substances and humification parameters. The vermicompost products were chemically characterised and the thermal properties of selected vermicompost samples were determined and compared to compost mixed with different amounts of charcoal as well as soil samples. This was done not only because of the potentially beneficial effects of the carbon (C) contained within the charcoal but also because the charcoal could provide a potential sink for atmospheric C, sequester nitrogen oxides and might increase the degree of OM stability.

## MATERIALS & METHODS

The experiment was conducted in a greenhouse in 40 L pots, with a depth of 47.0 cm and diameter of 44.0 cm. The pots were lined with polypropylene wire mesh (0.56 mm aperture) and a layer of gravel (3.0 cm thick) was added. Oak (*Quercus robur*, QR) woodchips were used for the present investigation due to the availability of the wood and since preliminary investigations showed that oak woodchips gave the best results in terms of the rate of composting and quality of the compost. The wood was crushed to form woodchips (2.0 x 0.2 cm) and soaked in water for 24 hours before use to advance the composting process by creating a pulp. After soaking, the QR woodchips were mixed with horse manure (HM) and lake mud (LM), respectively, at mixing ratios (w/w) of 1QR:2HM and 1QR:2LM. The HM and LM serve as nitrogen (N) sources and this ratio was applied in order to obtain a C/N ratio of the mixtures in the range of 25 to 30 (McClintock, 2004). The pots were filled with the mixtures to a depth of

40.0 cm and covered by the net. The chemical properties of the wood (QR), HM and LM are summarised in Table 1. Each mixture (1QR:2HM and 1QR:2LM) was repeated in 6 pots, which was divided into two plots (3 pots/plot). All pots were irrigated by compost water for the first 30 days to add microorganisms that will improve the composting process. Thereafter irrigation was with tap water until the end of the experimental period (100 days). The compost water was obtained from Pro Arkades (Neuendorf, Brandenburg). The chemical properties of the tap and compost water are provided in Table 2. After 30 days the first plot of each mixture was inoculated with *Eisenia fetida* (EF) at a rate of 25 earthworms/kg mixture (Maboeta & Van Rensburg, 2003), while the second plot was left without an earthworm inoculum. This was done to avoid exposure of earthworms to the possible high temperatures during the initial thermophilic phase of composting (Frederickson *et al.*, 2007). The moisture level of all pots was maintained at 55% during the composting and 75% during the vermicomposting period, where the relevant type of water was added to the pots to maintain the required moisture level.

The compost samples were collected at 7, 14, 28, 42, 56, 70, 84, and 100 days of the composting period, air dried and sieved through a 2 mm sieve. The extraction was carried out on 2 g of each compost sample with 100 ml of 0.1M NaOH/Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub> solution for 48 h at 65°C (Kononova & Bel'chikova, 1961). Samples were centrifuged at 2500 rpm and supernatant solution filtered through a 0.45 µm Millipore filter and 10 ml of the supernatant was acidified with 0.5M sulphuric acid (H<sub>2</sub>SO<sub>4</sub>, pH 2). The solution was evaporated in a water bath and the C content (HA+FA) was determined by wet oxidation according to the method of Springer & Klee (1954). Humic and fulvic acids were fractionated by acidification of 25 ml of the extract with H<sub>2</sub>SO<sub>4</sub> (50%), separating HA (precipitated) from FA (in solution). The precipitated HA were separated from FA, resolubilised with hot 0.1M NaOH and quantitatively transferred into a calibrated 50 ml flask, brought to volume with 0.5M NaOH. The C content of HA solution was then determined by the same method. The FA is estimated by subtracting the HA from the summation of (HA+FA). Total extractable carbon (TEC) was determined following the procedure

**Table 1. Chemical properties of compost raw materials**

Properties	QR	HM	LM	Reference
Organic matter (%)	98.5	62.3	24.9	DIN (2000)
Total organic carbon (%)	47.7	32.3	14.5	Springer & Klee (1954)
Total carbon (%)	50.8	32.3	18.3	
Total nitrogen (%)	0.2	2.3	1.2	Tabatabai & Bremner (1991)
Carbon/Nitrogen ratio	317	14	16	
Total Phosphorus (mg/kg)	154	2823	412	Rodriguez <i>et al.</i> (1994)
Total Potassium (mg/kg)	383	10320	7311	
Total Calcium (mg/kg)	320	5260	17754	
Total Magnesium (mg/kg)	89	2033	1564	
Total Copper (mg/kg)	3.64	15.80	13.32	DIN ISO (1997)
Total Iron (mg/kg)	279	2733	7709	
Total Manganese (mg/kg)	53.8	149.5	471.9	
Total Zinc (mg/kg)	4.69	76.6	64.19	

**Table 2. Chemical properties of the tap and compost water**

Properties	Tap water	Compost water	Reference
EC (Ds/m)	1.15	12.33	APHA (1998)
pH	7.45	5.14	
P (mg/L)	0.20	1407	Watanabe & Olsen (1965)
K (mg/L)	235	2510	
Ca (mg/L)	107	2490	
Mg (mg/L)	13.0	420	
Fe (mg/L)	0.01	10.88	APHA (1998)
Mn (mg/L)	Traces	19.0	
Cu (mg/L)	0.08	0.44	
Zn (mg/L)	0.50	8.10	

proposed by Ciavatta et al. (1990). Degree of humification (DH) and humification index (HI) were calculated using the following equations (Eq. 1, 2) reported by Ciavatta et al. (1990). The HI is the ratio between the nonhumified fraction (NH) and the humified fraction (HA + FA):

$$DH (\%) = 100 (HA + FA) / TEC \quad (\text{Eq. 1})$$

$$HI = NH / (HA + FA) \quad (\text{Eq. 2})$$

Where:  $NH = TEC - (HA + FA)$

The pH was measured in a suspension of compost and 0.01M CaCl<sub>2</sub> (1:10 w/v) after shaking for 30 min (Suzuki *et al.*, 2004). Cation exchange capacity (CEC) was determined by using the BaCl<sub>2</sub> method (Hendershot & Duquette, 1986). Available compost content of potassium (K) was measured by atomic absorption spectrometry (AAS 1100B, Perkin-Elmer) after extraction with ammonium acetate-ethylene diamine tetra acetic acid (EDTA) (Cottenie *et al.*, 1982). Available phosphorus (P) was estimated according to Bray and Kurtz (1945). Available N was determined by extraction with potassium chloride solution (KCl, 2.0M) and analysed colorimetrically (Dahnke, 1990).

Thermogravimetric (TG) and different thermal analysis (DTA) methods were used to investigate the thermostability of the vermicompost. These analyses are based on programmed heating of the sample in a controlled atmosphere. Simultaneously, thermal tests were performed on a thermo balance L81Fa (Linseis, Germany) in vertical operation mode, using platinum crucibles with a heating rate of 10°C min<sup>-1</sup> from 0 to 800° C under dynamic air atmosphere (100 ml min<sup>-1</sup>). The reference material for the compost DTA-measurements was ignited aluminum oxide (Al<sub>2</sub>O<sub>3</sub>). For interpretation, the software STA (TG measurement) and Linseis (DTA measurement) were used (Friedrich *et al.*, 1996).

Compost samples produced from the 1QR:2HM+EF and 1QR:2LM+EF mixtures were analysed after manual grinding in an agate mortar. The thermostability of the compost was compared to that of soil obtained from the Niedermoor area (0 – 30 cm), Potsdam, Germany. This soil was characterised by OM content of 9.63%. In addition, the effect of charcoal as a source of C on compost stability was examined. The compost used in this instance, was that produced from the 1QR:2HM+EF mixture, mixed with the following application rates of crushed charcoal: 3.0, 6.0, and 12.5%.

The data obtained was statistically analysed using analysis of variance (ANOVA). The treatment means

were compared using the Least Significant Difference (LSD) range test at a 5% level of probability (Snedecor & Cochran, 1989). All statistical analyses were performed with the COSTAT software package (Version 6.311, Monterey, CA, USA). All data presented represent the averages of three replicates.

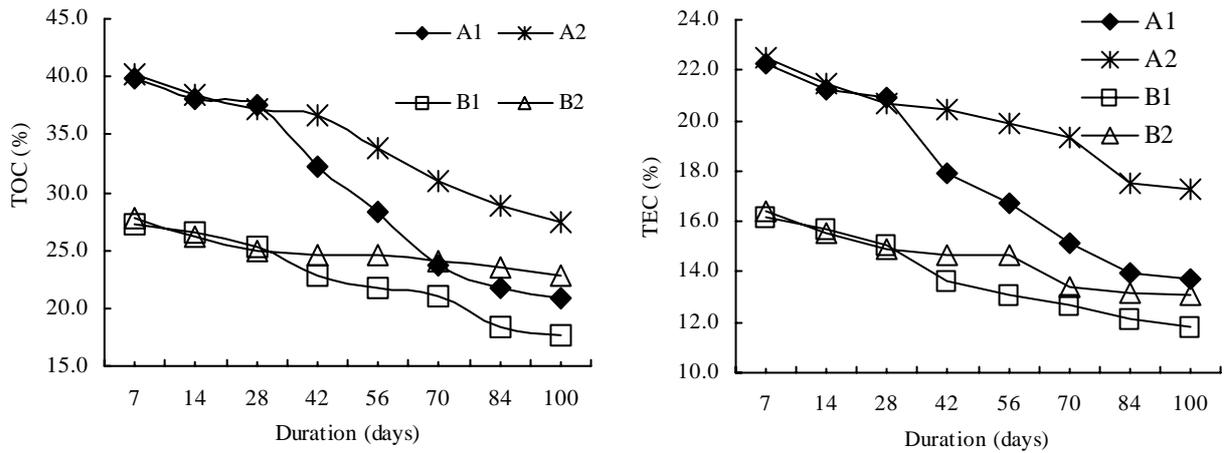
## RESULTS & DISCUSSION

The data presented in Fig. 1 shows the effect of the different treatments on the TOC and TEC content (%) over the composting period. Treatments included woodchips mixed with HM and LM, respectively in duplicate and one of each of these mixtures were inoculated with earthworms (EF): A1= 1QR:2HM + EF, A2= 1QR:2HM, B1= 1QR:2LM + EF, B2= 1QR:2LM. The results show a general decrease in TOC and TEC content over the composting period, with lower overall values for the treatments containing LM. The decrease over time can be ascribed to a combination of mineralisation of OM by the microorganisms and earthworms as well as the oxidation of C to CO<sub>2</sub> by microorganisms during the composting process. The initial decline in TOC and TEC could be attributed to the degradation of readily degradable C substrates, such as carbohydrates and hemicelluloses, whereas other C sources, such as lignin will be degraded more gradually and thus only during the final composting stages.

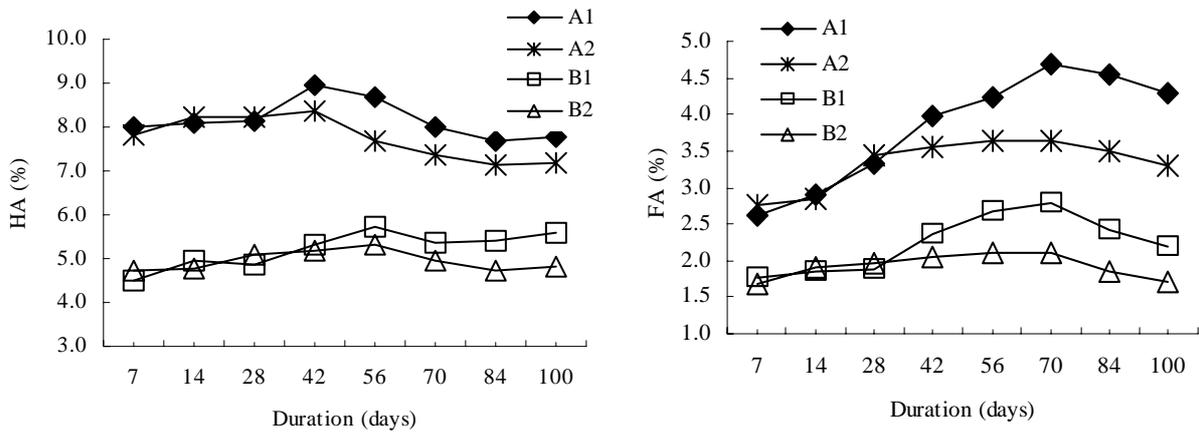
Throughout the composting process, the rate of TOC and TEC decline in the wood mixed with HM treatments was higher than that of the wood mixed with LM. This shows that the TOC and TEC evolution rates during composting of the wood were influenced by the initial C/N ration of the raw materials. Furthermore, the higher amount of N, P, and microorganisms in HM compared to LM (Table 1), probably accelerated the degradation process (Desalegn *et al.*, 2008).

In both the HM and LM treatments, TOC and TEC content decreased more over the composting period for those treatments inoculated with EF (Fig. 1, A1 and B1). The acceleration of mineralisation was to be expected since the beneficial effect of these earthworms on the composting process is well known (Aira *et al.*, 2002; Edwards, 2004).

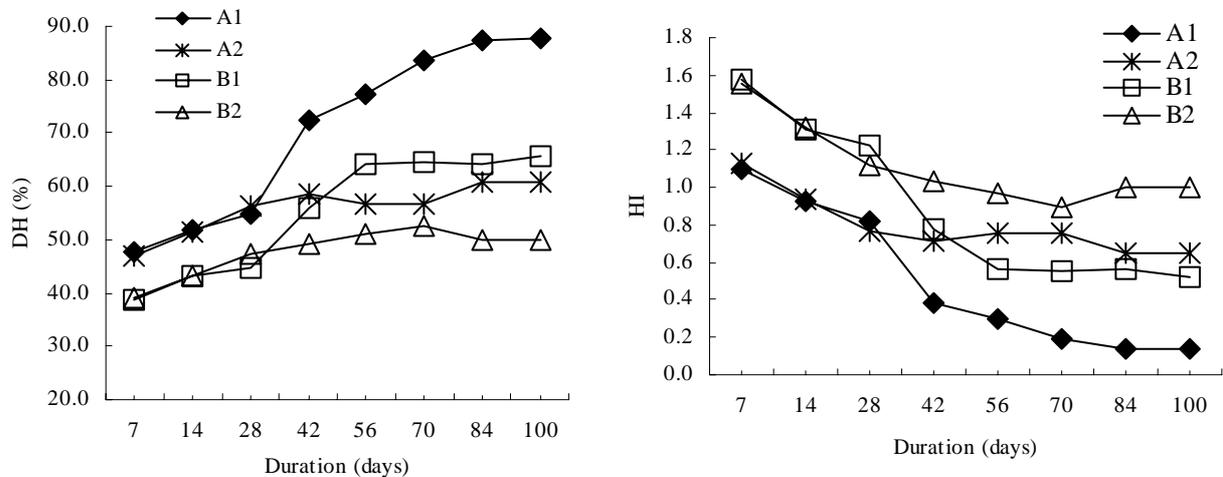
The data presented in Fig. 2 shows the changes in HA and FA content over the composting period. The data presented in Fig. 3 shows the changes in the DH and the HI during composting of wood with different treatments. Treatments included woodchips mixed with HM and LM, respectively in duplicate. One of each of these mixtures was inoculated with earthworms (EF). In order to evaluate the maturity level of the organic matter produced by the composting process,



**Fig. 1. Total organic carbon (TOC) and total extractable carbon (TEC) over the composting period with different treatments. A1= 1QR:2HM + EF, A2= 1QR:2HM, B1= 1QR:2LM + EF, B2= 1QR:2LM**



**Fig. 2. Humic acid (HA) and fulvic acid (FA) content over the composting period with different treatments. A1= 1QR:2HM + EF, A2= 1QR:2HM, B1= 1QR:2LM + EF, B2= 1QR:2LM**



**Fig. 3. The degree of humification (DH) and humification index (HI) over the composting period with different studied treatments. A1= 1QR:2HM + EF, A2= 1QR:2HM, B1= 1QR:2LM + EF, B2= 1QR:2LM**

humification parameters were used. The results (Fig. 2) show a change in HA and FA over the composting period and both parameters were affected by the different treatments. The HA and FA content (%) was higher for the 1QR:2HM+EF and 1QR:2HM treatments than for the 1QR:2LM+EF and 1QR:2LM treatments over the composting period. Furthermore, those treatments inoculated with EF showed higher HA and FA contents than the treatments without any earthworms. The higher HA and FA values in the HM treatments when compared to the LM treatments can be due to higher microbial activity in the HM and consequent increased decomposition. As seen in the TOC and TEC contents as well (Fig. 1), inoculation of treatments with earthworms was beneficial to the composting process.

The highest percentage of HA was determined on day 42 for the 1QR:2HM+EF and 1QR:2HM treatments. For the 1QR:2LM+EF and 1QR:2LM treatments, the highest percentage of HA were observed on day 56. The percentage FA was found to increase over the composting period, reaching a maximum on day 70, followed by a gradual decline. The initial increase in both HA and FA across treatments can be ascribed to a high content of soluble organic substances and high levels of microbial activity, whilst the decrease in FA during the final composting stages, is due to the transformation of FA to create stable HA compounds, utilisation of the FA due to microbial activity and rearrangement of organic acid functional groups (Aira *et al.*, 2002; Desalegn *et al.*, 2008; Veeken *et al.*, 2000). The observation that HA content was higher than FA content for all treatments over the composting period (Fig. 2) may be a function of the chemical composition of the raw materials. The proportion and structure of wood components (cellulose, hemicellulose and lignin) and their degradability affect the formation of HA and FA (Huang *et al.*, 2006).

The DH and HI were also determined to assess compost maturity (Fig. 3). As expected, the DH increased over the composting period for all treatments, reaching more stable levels after day 56 for all treatment, except 1QR:2HM+EF. Up to day 42, the highest DH was recorded for in those treatments with HM. Again, both the HM and LM treatments with EF showed higher values than the treatments without EF. This confirms the enhanced humification effect of the earthworms on the composting process. The calculated HI values (Fig. 3), were observed to gradually decrease over the composting period, varying in accordance with the theoretical substrate availability and increased stability of the organic matter in the compost. The HI has been used as a quantitative indicator of the degree of compost maturity (Ciavatta *et al.*, 1990, 1993), with a

HI value of  $\leq 0.5$  indicating stabilised compost. From the results obtained, the positive effect of the HM treatment inoculated with EF on degradation of QR wood is apparent in this regard.

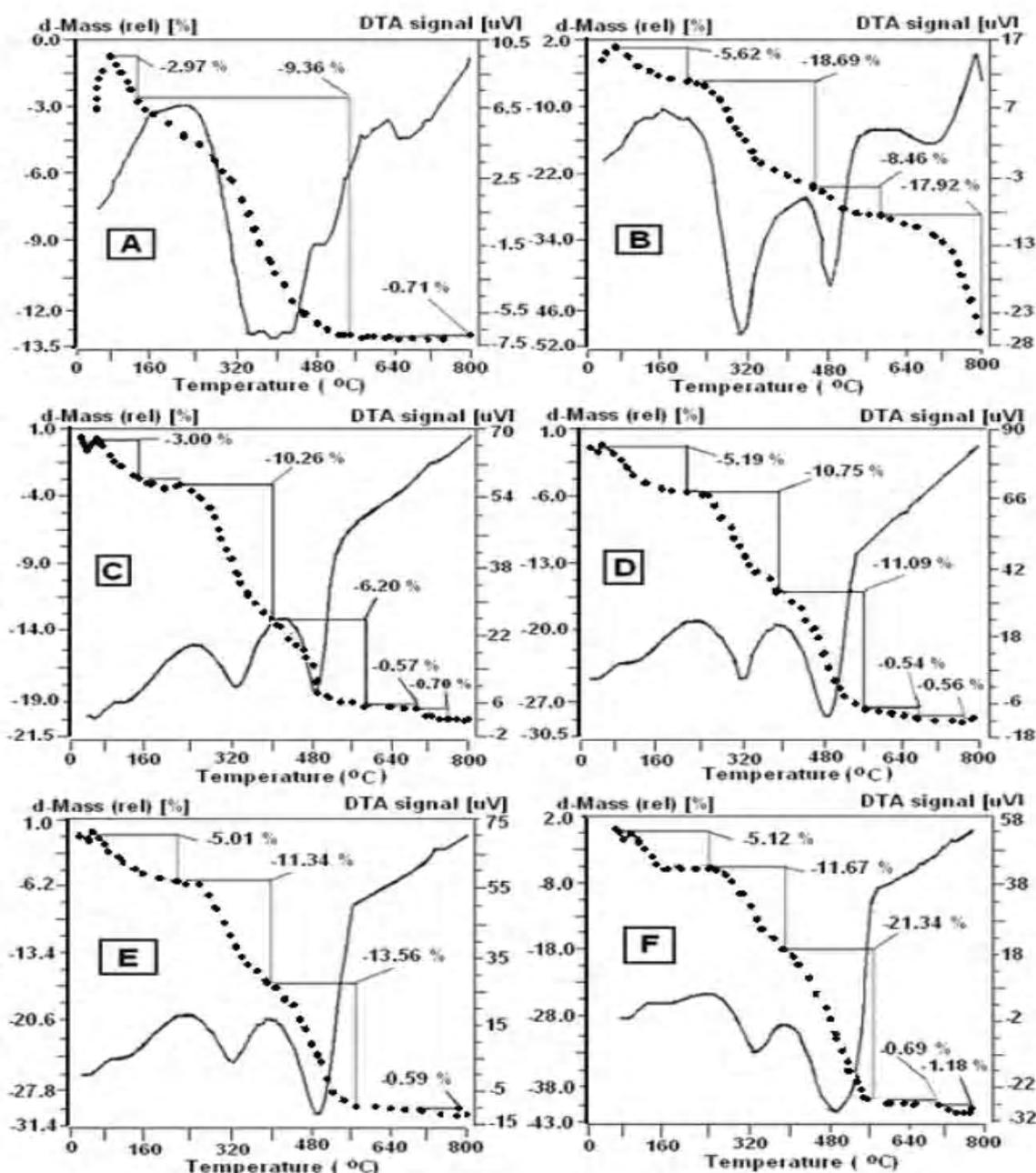
The effect of the different N sources (HM and LM) on selected chemical properties of the compost product and the available nutrient content was investigated (Table 3). Significant ( $p < 0.05$ ) differences could be observed between the different treatments. The pH and C/N ratio of compost produced from the HM mixtures (A1 and A2), were lower than that of the corresponding LM mixtures (B1 and B2), with the lowest values recorded in the EF inoculated treatments. The lower pH values typifying the HM treatments may have resulted from higher rates of mineralisation and/or bioconversion of organic materials to intermediate species of organic acids (Ndegwa *et al.*, 2000). The highest OM content was observed for the 1QR:2HM treatment (A2), followed by 1QR:2LM (B2), 1QR:2HM+EF (A1) and 1QR:2LM+EF (B1). The CEC of wood compost containing HM was higher than that of wood mixed with LM. In this regard, it can be noted that the higher humic fractions in HM treatments result in an increased CEC (McClintock, 2004). Values of available N, P and K in the compost produced from wood mixed with HM were also higher than those produced from wood and LM. The sequence for available N, P and K in all treatments were  $A1 > A2 > B1 > B2$ . Although this sequence to a large degree reflects the chemical composition of the input materials (Table 1), it supports the observation that mixing with HM and inoculation with EF was more beneficial to the composting process than mixing with LM and not inoculating the compost mixture.

Thermal analysis data from TGA and DTA of soil (A), QR wood compost (B, C) and compost mixed with charcoal (D, E, F) are presented in Fig. 4. The TGA and DTA of soil (A), QR wood compost (B, C), and compost combined with charcoal (D, E, F) (Fig. 4) provides information on the mass loss of samples as a function of temperature. From these data, it is evident that the TGA curve of the compost samples could be divided into four mass regions opposed to the three mass transitions of the soil sample. The corresponding DTA curves indicate that the first step of mass loss is always an endothermic reaction that in all probability originates from the dehydration of free and bound water that exist between 100°C and 200°C. Differences in the intensity of endothermic peaks among the studied materials can be attributed to different amounts of absorbed water. Up to 200°C the highest values of free and bound water was recorded for sample B (5.62%) followed by D (5.19%), F (5.12%), E (5.01%), C (3.00%) and finally sample A (2.97%), a sequence that reflects the effect of the OM content of the samples studied

**Table 3. Selected chemical properties and available nutrient content of wood compost as affected by different nitrogen sources**

Treatments	pH	OM (%)	CEC (cmol/kg)	C/N ratio	Available nutrients (mg/kg)		
					N	P	K
A1	6.72c	35.42c	53.52a	10.90c	5526a	131.1a	780a
A2	6.92b	47.38a	51.30b	16.51b	5135b	105.1b	714b
B1	7.30a	30.50d	46.82c	15.11b	3511c	37.9c	482c
B2	7.38a	37.58b	43.72d	22.05a	3276d	28.5c	441c
LSD <sub>0.05</sub>	0.15	1.88	1.73	2.06	215.34	20.15	66.13

Mean of the same category followed by different letters are significantly different at 0.05 level of probability (LSD: Least Significant Difference); A1= 1QR:2HM + EF, A2= 1QR:2HM, B1= 1QR:2LM + EF, B2= 1QR:2LM



**Fig. 4. Thermogravimetric (dotted line) and different thermal analysis (black line) curves of different treatments. A = Soil, B = 1QR:2LM+EF, C = 1QR:2HM+EF, D = 1QR:2HM+EF+ 3.0 % charcoal, E = 1QR:2HM+EF + 6.0 % charcoal, F = 1QR:2HM+EF + 12.5 % charcoal**

(lowest in soil sample). Mass losses above 200°C are mainly connected to exothermic reactions due to combustion of the OM. The exothermic reaction process in the soil sample (A) occurred in the range up to 550°C and resulted in a 9.36% mass loss. The last endothermic reaction peak for the soil was observed at around 600°C (between 550°C and 760°C), characterising the de-carbonisation of calcite (CaCO<sub>3</sub>), with loss of CO<sub>2</sub>. This can be attributed to a phase transition of quartz and pyrolysis. On the other hand, the TG losses of the compost samples revealed four mass transitions between 200°C and 800°C. The mass losses for all samples varied as indicated in Fig 4. This is the result of the decomposition of aliphatic structures, phenolic acids, mono and polysaccharides, and partly cellulose. Also, at these temperatures humic acids tend to accumulate during the composting process as lignin decomposes and OH and COOH groups are reduced (Fares *et al.*, 2005). As the compost becomes more stable, products that burn within the range of 200 to 430°C disappear (Smidt and Lechner, 2005). This also implies that the addition of charcoal had no effect on the degree of thermal stability of OM in this region. Increasing application of charcoal resulted in an increased amount of easily combustible OM as reflected by the TG loss curve. It has been indicated that between 400 and 550°C, the weight loss is mainly due to the decomposition of aromatic polycondensates with the lowest oxygen content and stable moieties either naturally occurring in the sample or resulting from molecular rearrangements (Lopez-Capel *et al.*, 2005; Dall'Ara *et al.*, 2008). The highest mass losses (21.34%) were recorded for sample F followed by sample E (13.56%), D (1.09%), B (8.46%) and C (6.20%). Clearly, HM enhanced decomposition of wood and consequently decreased the readily available oxidisable organic forms compared to LM. In this regard, it is worth noting that an increased application rate of charcoal resulted in an increase in the combustion and subsequently increased the mass loss. At the same time, charcoal had no effect on compost OM stability.

Finally, the weight loss at temperatures higher than 550°C was associated with endothermic oxidation of refractory C as well as with the decomposition of both mineral and biogenic salts. The mass loss in this transition is due to the CaCO<sub>3</sub> decarboxylation (Dall'Ara *et al.*, 2008). Moreover, this can be due to thermal decomposition of the remaining lignin pyrolysis products (e.g. p-coumaryl, coniferyl, and sinapyl alcohols). In comparison with the soil sample, the compost samples were slightly less thermostable when considering the first exothermic peak due to compost potentially containing a higher amount of labile and

soluble OM compared to soil. The high amount of cations in compost compared to soil may also have an effect on the OM stability. Nevertheless, the compost samples seems to be more thermostable in the second exothermic reaction which reflects the high amount of fulvic acid and aromatics components, when compared with their counterparts in soil (Dall'Ara *et al.*, 2008; Fares *et al.*, 2005). The effect of an increased addition rate of charcoal could be observed in the increasing amount of mass lost in each thermal transition and is due to the high amount of pyrolysis products.

## CONCLUSION

It can be concluded that composting of QR woodchips was differentially influenced by different variables monitored. During the composting period, there was a high level of organic matter evolution, as reflected by the changes in TOC and TEC as well as of the humification parameters. The decrease of TOC and TEC contents with time, associated with an increase towards constantly high values of DH and the decrease in HI values suggest the reaching of an acceptable level of compost maturity. The CEC and available nutrients (N, K, P) were higher in compost produced from 1QR:2HM than that of the 1QR:2LM mixture, while the compost pH values were reversed in these treatments. The data presented clearly indicate that inoculation with earthworms had the most pronounced effect on the different parameters examined. Although being slightly less thermostable during the first exothermic peak, the compost samples seemed to be more thermostable during the second exothermic reaction when compared to soil. Also, the compost produced from wood mixed with HM was more thermostable than that produced from a wood and LM mixture. The addition of charcoal to the vermicompost had no effect on the degree of OM thermostability. Only by increasing the charcoal application rates could an increased amount of mass loss in each thermal transition be achieved.

The relevance of this investigation pertains to the advantages gained from composting wood wastes instead of burning the wood. Composting reduces the amount of fossil fuels produced and can also be used as a soil amendment. The reduction in fossil fuels emissions is especially important with regard to legislation requiring a reduction in CO<sub>2</sub> emissions in most countries.

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