Characterization of compost as affected by manipulation of C/N ratio

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ABSTRACT

An aerobic composting experiment was conducted for 91 days in the laboratory of the Department of Soil and Environment Sciences, Faculty of Agriculture, University of Khartoum, Sudan to investigate the effects of three levels of C/N ratio on some physico-chemical properties of final compost from sheep manure (C/N 15.9), groundnut straw (C/N ratio 25.9) and their mixture (C/N ratio 18.3). Increase in C/N ratio of materials had consistently resulted in an increase in pH, increase of the final compost and the increase was 5, 36 and 68%, respectively. Total N, P, K, Mg, pH, WHC and bulk density were increased in final compost whereas organic C, lignin, polyphenol and C/N ration showed variable reduction. Characterization of final compost generally depends on initial C/N ratio of the materials used.

Key words: Aerobic compost, C/N ratio, Groundnut straw, Sheep manure.

Composting is an organic matter decomposition process under aerobic conditions (Vlyssides et al., 2009) and is considered a cost-effective biological treatment and stabilization method for solid waste, particularly manure (Nasiru et al., 2013). Composts are recently used in wide scale agriculture as soil conditioners and amendments. Addition of high rates of good quality compost is a suitable management practice in amelioration of degraded soils in the semi-arid region (Hernández et al., 2015). Addition of compost has been reported to increase various soil quality parameters. For example, total soil porosity (Aggelides and Londra, 2000), water-holding capacity (Curtis and Claassen, 2005), structural stability (Tejada et al., 2009), amount of available nutrients (Weber et al., 2007), nutrient-sorption capacity (Weber et al., 2007) were increased with compost addition and it also improves microbial growth and population (Macci et al., 2012). Effects of compost on cropping systems may vary according to the materials used and potential limitations may includes high bulk density, salinity, residual phytotoxicity, pH and rate of residual degradation with time (Raviv, 2011). Ideal C/N ratio of 20/1 to 30/1 is needed for bacterial growth during composting (Estévez-Schwarz et al., 2012) and could also be as high as 32.2/1 (Makan and Muntadar, 2012). Higher hemicellulose content and a lower C/N ratio can result in a higher rate of degradation of organic matter and consequent contents of humic-like substances, while a higher content of lignin can lead to a higher polymerization degree of humic substances in compost piles (Zhao et al., 2016). It should also be noted that within optimum C/N ratio range (25/1), losses of N could be as high as 70.7% of initial N content (Ogunwande et al., 2008). Addition of fine-textured soil to compost can reduce N and P leaching, which could enhance and prolong the positive effects of compost on soil fertility (Nguyen and Marschner, 2013). Aeration rate was the main factor influencing compost stability, while the C/N ratio mainly contributed to compost maturity (Guo et al., 2012). In short optimum aeration and C/N ratio of source material, and less N loss during the process are considered essential for a proper compost mixture (Cayuela et al., 2009). In Sudan, average production of farm yard manure varies between 115500 and 193000 t day⁻¹ which could be a potential source for compost production (Mubarak and El Amin, 2007). Hence the present study was carried out with the aim of investigating the effects of various C/N ratios on the composting process and characterization of the final composites.

Initial organic materials viz., sheep and groundnut straw were collected from the main sheep wholesale market and during this time they were fed on straw. Some chemical properties of the materials used for composting are given in Table 1. Three C/N ratios such as sheep manure (SM) 16/1, groundnut straw (GS) 26/1 and a mixture (MIX) of SM and GN 18/1 were used. About 1150, 500 and 250 g of air dried SM, MIX and GN were added to composting cork containers having 15 cm diameter, 30 cm height and aerobically composted at 60-70% of water holding capacity (Karak et al., 2014) until maturity (ambient and compost temperatures are equal). Aerobic condition was maintained by covering the containers with perforated plastic material and periodically opened every week for gas exchange. Further aeration technique was also kept by turning the compost material every two weeks. Containers were arranged in a completely randomized block design with four replications.
Throughout the incubation period, water content was maintained through regular weighing and any loss was substituted with distilled water. During the first week, compost temperature was recorded on daily basis, then after recorded every week. During the first week of composting, temperature was daily recorded then after it was recorded every week. The competition of the composting process (also known as compost maturity) was determined when compost and ambient temperatures were similar (Flynn and Wood, 1996).

**Analysis:** At maturity, compost samples were collected and analyzed for the change in pH, TN, OC, P, soluble K, Ca, Mg (Chapman, and Pratt), lignin (van Soest and Robertson, 1985), polyphenol (Tian et al., 1995), water holding capacity and bulk density. Data was statistical analyzed using software of SAS (1999) and differences between means were separated using Least Significant Difference (LSD).

Physico-chemical properties of the initial material and final compost were shown in Table 1. The pH of the initial materials varies from acidic (GS) to neutral (SM and MIX) whereas OC in the GS was higher than SM and MIX by 20-27%. Also, both lignin and PP in the GS were higher than SM and MIX by about 25-58 and 16-24%, respectively. The pH of the final compost of MIX and GS showed significant increase (9-11%) over SM. There was a clear and consistent increase in pH where initial materials with C/N ratio of about 16, 18 and 25 and the increase in pH was 5, 36 and 68%, respectively. In a study elsewhere (Eklind and Kirchmann, 2000), higher microbiological activity resulted in a higher NH$_3$ production due to the mineralization of the organic nitrogen and that was reflected in the elevated pH. Lower C/N ratios (16-18) produced final compost with higher (by 112-238%) TN than that with initial materials having high C/N ratio (25). High initial C/N ratio (18-25) have resulted in lesser increase of K (84-99%) in final compost compared to low C/N ration (16) which (106%). Adediran et al. (2003) reported that as composting of organic wastes proceeded, the pH decreased slightly and reached a level of 7.2 in the first 5 days then after composting showed gradual rise in pH to a value of 8.5 for soybean based compost. Also, the same authors reported TN, organic C and some micronutrients were significantly increased. It was reported that C/N is among one of the important factors affecting compost quality (Michel et al., 1996). Bhamidimarri and Pandey (1996) have recommended maintaining C/N at 25–30 as the optimum ratio for composting. Compost produced from materials with high initial C/N ratio (26) and high lignin content (175.8 g kg$^{-1}$) showed the highest TC carbon loss (41%) which is in line with Nolan et al., (2011) who recorded a reduction of 40%. The concentration of P and Ca showed erratic pattern with initial C/N ratio of the materials. In all compost materials, reduction in C/N ratio was almost similar and ranged from 50 to 68%. However, initial C/N ratio of
26 has resulted in higher increase (171%) of Mg in final compost than that found (19-76%) in compost with initial C/N ratio of 16-18. Increase TN (6-71%), P (13.6-34.9%), K (7-37%) and decrease in C/N ratio (10-42%) of the composts were earlier reported by many researchers (Adediran et al., 2003; Noalan et al., 2011). The clear increase in C, TN and pH in the final compost of the MIX material could possibly be attributed to the improved quality of initial material. Mixing low with high quality materials was reported to improve decomposition of materials and release more N (Zhang et al., 2013). Lignin content was markedly decreased by 53-61% when compost was produced from initial materials with both high C/N ratio (18-26) and lignin (140-175 g kg\(^{-1}\)) compared to a decrease of only 19% in the materials having both low C/N ratio (16) and lignin content (112 g kg\(^{-1}\)). Similar to lignin, PP content was also reduced (52-68%) in both high C/N ratio (18-26) and PP (445-517 g kg\(^{-1}\)) compared to a decrease of 38% in low initial C/N ratio (16) and PP content (418 g kg\(^{-1}\)). Compost produced from initial material with C/N ratio of 26 has significantly higher by 20-31% WHC than that produced from low C/N ratio (16 and 18). The bulk density of both initial and final compost is closely related to the C/N ratio of the initial materials and it follows the order of C/N ratio of 16 > 18 > 26. Increase in WHC and bulk density after composting is also earlier recorded (Bachman and Metzger, 2007; Adediran et al., 2011).

In the first week of composting, SM manure (low C/N ratio) recorded the highest temperature compared to other treatments. This is inconsistent with Huang et al. (2004) who found a slower rise in temperature during aerobic composting of pig manure with 15 C:N compared to pig manure mixed with sawdust (C/N of 30). This discrepancy might be attributed to the differences in initial materials used for composting. In all composts, the maximum temperature (37.5 to 42 °C) was attained after three weeks where SM recorded the highest value (Fig 1). Then after, compost temperature continued to record decreasing values. It was observed that after each turning, there was a slight increase in compost temperature which could be due to increased available C sources for microorganisms. In degraded dry lands where water shortage is a concern, compost production from groundnut materials and sheep manure may have positive effects on soil water storage capacity.

REFERENCES


