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Variability of physiochemical properties of livestock manure with added wood shavings during Windrow Composting

Fabrice L. Yengong[1*], Veronica E. Manga[1], Ngwa M. Ngwabie[2], David T. Tiku[1] and Esongami N. Eric[1]

[1]Department of Environmental Science, Faculty of Science, University of Buea, Cameroon.
[2]Department of Agricultural and Environmental Engineering, College of Technology, the University of Bamenda, Bambili, Cameroon.

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Composting livestock manure still remains one of the best waste-to-resource technologies practiced in the world. There is however, limited information on composting of livestock manure and wood shavings in Cameroon. This research, carried out in South West Region of Cameroon assesses the variability of physiochemical properties: pH, pile temperature, mass, volatile solids contents (VS), total solids (TS) and total organic carbon (TOC) of livestock manure with added wood shavings during windrow composting. Different proportions of cow manure (CM), pig manure (PM), fowl manure (FM) and wood shavings (WS) were used in the research over a period of 25 days during the dry season in 2020. The mass and temperature were determined everyday while pH, VS and TOC were measured every three days. Comparing different livestock manure amended with wood shavings to its corresponding raw manure during windrow composting showed that, there was an insignificant difference in the VS and TOC and a significant mass reduction. Similarly, there was a significant difference in temperature between FM+WS and FM and an insignificant difference in temperature in both CM+WS and CM as well as in PM+WS and PM. When comparing only amended livestock manures with wood shavings during windrow composting, it was observed that, in all the amended livestock manure combinations, only temperature and pH had a significant change while mass and VS had an insignificant change. Composting of livestock manure with woods shavings should be promoted since it enhances some physiochemical properties.

Key words: Livestock manure, wood shavings, composting, physicochemical properties.

INTRODUCTION

Poor waste management of livestock manure can create adverse environmental conditions such as pollution from various nutrients and organic compounds, emission of ammonia and other greenhouse gases, leading to health risks for human and animals. Therefore, it is necessary to find a suitable alternative to reduce the environmental problems associated with management of manures. Composting is one of the best-known processes for the biological stabilization of solid organic wastes by transforming them into safer and more stabilized agricultural applications (Fischer and Glaser, 2012). Among the different types of composting, windrow composting is known for its low capital cost, relatively simple operation and eco-friendliness (Vigneswaran et al., 2016).

The composting process is characterized by its laborious nature of reducing the bulky mass of organic waste to smaller volumes and weights (Yamada and Kawase, 2006), stabilizing ammonical nitrogen (Li et al., 2013) and destroying the potentail of pathogenic threats (Thyagarajan et al., 2013). This process is governed by physiochemical parameters such as: pile temperature, moisture content, volatile solid, total solid, pH, carbon-to-nitrogen ratio, total organic carbon (TOC) and electrical conductivity. These parameters are affected by the aeration rate when windrow composting is carried out (Romeela and Ackmez, 2005). In order to produce quality compost, it is important to monitor and control the parameters that affect the decompostion process.

Bulking agents play a critical role in arresting the leachate and for maintaining the aerobic condition (Dayanand et al., 2018). According to Jin et al. (2019), wood shavings were the most effective manure additive to livestock because of its enhancement for antibiotic removal and control of antibiotic resistance genes (ARGs) dissemination. Wood shavings also influenced the time necessary to reach similar organic matter (OM) stability and the biochemical evolution of OM. Depending on the biochemical nature, the bulking agent could increase nitrogen availability in the final composts by enhancing nitrogen organization and limiting losses by volatilization during composting (Doublet et al., 2011).

As such, this research was carried out to assess the variability of different physiochemical properties: pH, pile temperature, mass, volatile solids contents (VS), total solids (TS) and total organic carbon (TOC) during windrow composting of different livestock manure with and without the use of wood shavings as a bulking agent.

MATERIALS AND METHODS

Substrate collection

Livestock manure (Figure 1) used in this study was collected in Buea, the regional headquarters of the South West Region of Cameroon. Fresh pig manure was collected from fully concreted floor of a fattening pig building. The pigs were fed with crushed corn mixed with concentrate. Fresh fowl manure was collected from a caged building with a slatted floor. The fowls were fed with a finisher feed composting of corn, groundnut cake, sea shells and concentrate. Fresh cattle manure (mixture of stomach and intestinal wastes) was collected from the waste channel of a slaughter house. The cattle were West African zebu raised on pasture.

Wood shavings used in this study (Figure 1) were collected from a local mill. The wood shavings were a combination of flakes from about 30 to 50 years old eucalyptus tree (25%) and about 150 to 200 years old mahogany tree (75%). The flakes had a mean particle size of about 1 to 2 mm in diameter.

Composting facility

The livestock manure was composted at the waste-to-resource project site at the University of Buea. The facility is made up of 19 composting chambers; each with a dimension of 0.7 × 0.9 × 1 m. Each chamber has 3 closed walls with an open front and top (Figure 2). The closed walls are made of cement blocks at a height of 1 m from the ground. The floor of each chamber is fully concreted with a gentle slope that channels leachate outwards. The entire composting facility is roofed at a height of 3 m from ground.

Experimental set-up

Substrate preparation

Livestock manure and wood shavings were mixed at different mass ratios using a split experimental design protocol and introduced into the composting chambers with replicates as shown in Table 1. As such 12 out of the 19 chambers had substrates for composting. When more than one substrate was introduced into a chamber, the contents were homogenously mixed. The pile in each chamber was left to compost for 25 days. On each day of the composting duration, the pile in each chamber was weighed and moved to the next empty chamber, during which time mixing occurred.

Measurement of physiochemical parameters

On each day during the measurement duration, about 5 g of the contents in each chamber was subsampled into a beaker and the pH measured using an AL10pH portable pH meter (Aqualytic, Dortmund, Germany). The pile temperature in each chamber was measured at 3 locations using a compost thermometer (TFA Dostmann, Wertheim, Germany). The pile temperature was the average of the three readings.

The entire content in each chamber was weighed, after which it was reintroduced into an empty chamber. During this process, it is expected that the pile is aerated and re-mixed. The change in pile mass was calculated as the difference between previous day's mass and the current mass.

After weighing, aerating and mixing the pile in each chamber, a sample was collected for total solids (TS) and volatile solid (VS) determination using standard procedures in the laboratory (Telliard, 2001; Ngwabie et al., 2018). The total organic carbon (TOC) was then calculated in Equation 1 as indicated in Varma and Kalamdhad (2014).

$$\%TOC = \frac{\%VS}{1.8} \tag{1}$$

*Corresponding author. E-mail: lamfu2035yengong@gmail.com. Tel: +237678065758.

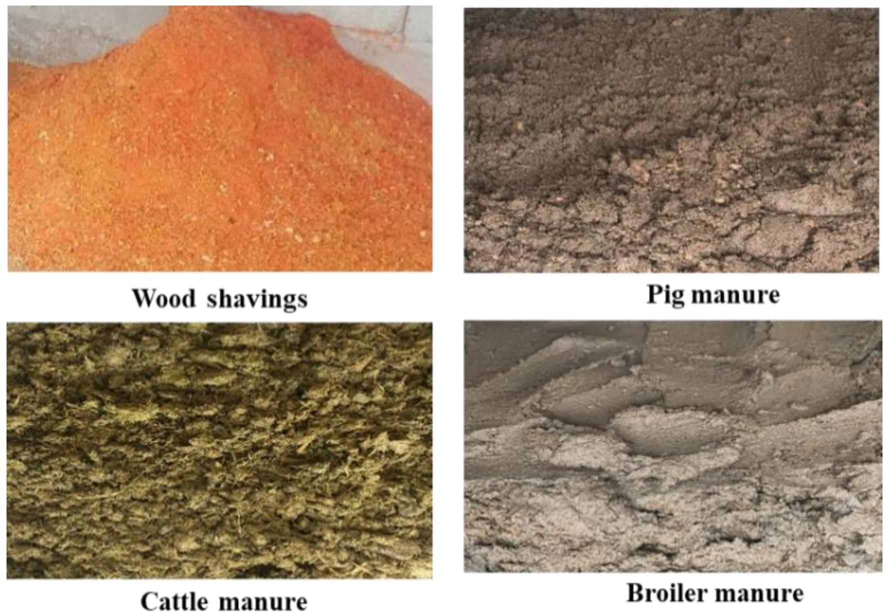

Figure 1. Different livestock manure substrates.

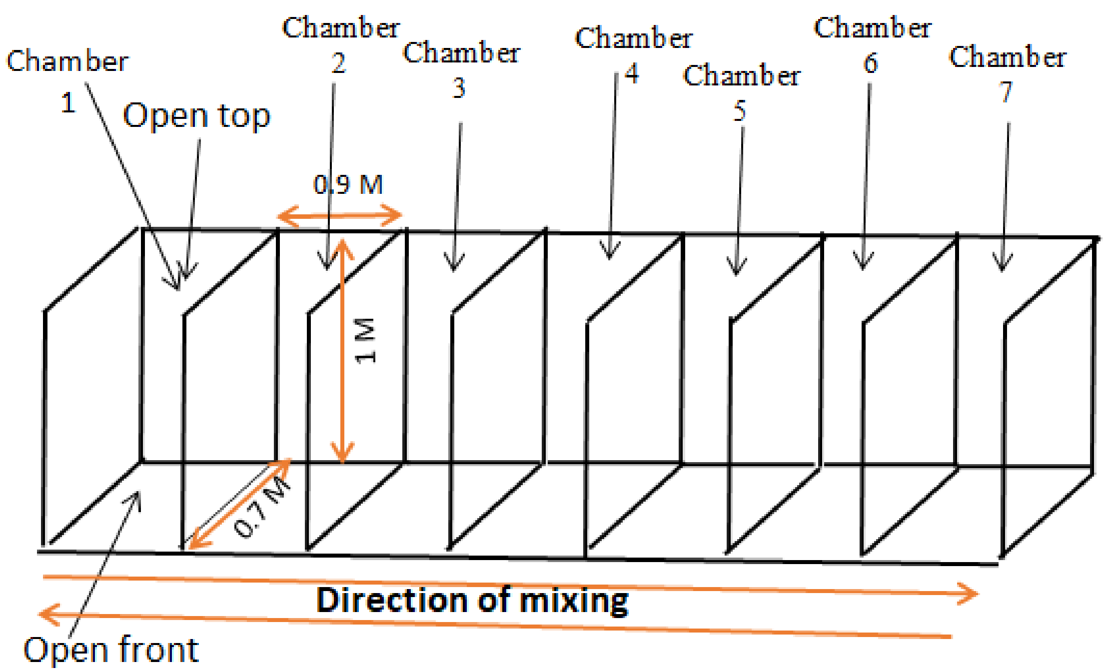

Figure 2. Schematic view of the windrow composting facility.

Statistical analyses

Statistical analyses of the data were carried out using MINITAB version 17. The physiochemical parameters and replicates for each day measurement were averaged and used in the entire analyses. The student t-test was used to assess differences in the physiochemical parameters of each livestock manure compared to its amendment with wood shavings. The analysis of variance test

Table 1. Manure and wood shaving ratios (kg) in different composting chambers.

Pig manure: Wood shavings	Cattle manure: Wood shavings	Fowl manure: Wood shavings
Chamber 1. 100:0	Chamber 3. 100:0	Chamber 5. 100:0
Chamber 2. 90:10	Chamber 4. 90:10	Chamber 6. 90:10
Replicates		
Pig manure: Wood shavings	**Cattle manure: Wood shavings**	**Fowl manure: Wood shavings**
Chamber 7. 100:0	Chamber 9. 100:0	Chamber 11. 100:0
Chamber 8. 90:10	Chamber 10. 90:10	Chamber 12. 90:10

(one way ANOVA) was used to assess differences in the physiochemical parameters of the different composting piles of all the livestock manure with added wood shavings. When differences were observed (p-value < 0.05), a post-hoc Fisher's LSD test was used to identify where they existed.

RESULTS AND DISCUSSION

Variations in the physiochemical properties of amended livestock manure vs. raw manure

Figure 3 shows the different trends of VS, mass, compost pile temperature and pH over the composting period. All the physiochemical parameters respected the normal trend as VS and mass reduce over time, temperature assumes a dome shape and pH stabilizes according to Romeela and Ackmez (2005).

Table 2 shows that the bulking agent (wood shavings) used had an insignificant role to play in the decrease of VS and TOC between the different livestock manure compared to the corresponding raw manure during windrow composting.

Wood shavings had a significant role to play in mass reduction between the different livestock manure when amended with wood shavings compared to its corresponding raw manure during windrow composting (Figure 3 and Table 2). Mass reduction is an indication of the fact that the compost is gradually completing its phase of decomposition; mass reduction also gives an idea on the type of substrate that is involved in the process; carbon rich substances will decompose faster than protein rich substrate (Haug, 1993).

As reported by Trautmann et al. (1996), temperature is one of the most important parameters in the composting process that indicates the activity of microbes, by determining the stages and progress of the compost piles. There was a significant difference in temperature between FM+WS and FM and, an insignificant difference between CM+WS and CM as well as between PM+WS and PM (Figure 3 and Table 2). This difference in FM could be because of the high moisture content in the FM, spaces between the composting pile hence reducing moisture content and increasing temperature (de Bertoldi et al., 1983; Adhikari et al., 2009).

pH remains one of the most important parameters governing the decomposition process during composting (Varma et al., 2014). The different mass ratios of livestock manure composted, mostly exhibited alkaline characteristics as seen in Figure 3, and showed an insignificant difference when amended with wood shavings compared to the corresponding raw manure during windrow composting (Figure 3 and Table 2).

Comparison of the physiochemical properties of different livestock manure when amended with wood shavings during windrow composting

In all the amended livestock manure combinations, temperature and pH had a statistical significant difference (Table 3). Temperature and pH are some of the most important parameters in any composting process that indicates the activity of microbes, by determining the stages and progress of the compost piles (Trautmann et al., 1996; Varma et al., 2014).

The significant difference in temperature observed between FM+WS and PM+WS was attributed to effect of WS added to the fine natured FM that increased the surface area for aerobes reaction than in PM+WS. Carbon rich substance (wood shavings) addition normally increases temperature but the magnitude of the change is determined by the fineness nature of the substance to which it is added on, which is in line with Adhikari et al. (2009).

The significant change in pH is closely linked to temperature change. During the mesophilic phase, pH increased which contradicts Mayur (2019), who observed pH increase in the themophilic phase. During the first Mesophilic phase, we had the highest pH in all the amended substrates, at the thermophilic phase, the pH generally decreased and at the second mesophic phase, the pH decreased further and stabilised as the so addition of wood shavings lead to an increase of air complete dump-shape temperature profile was formed. Increase in pH during the mesophilic phase is likely due to activity of proteolytic bacteria and the addition of wood shavings only, avoids pH fluctuations as compaired to the

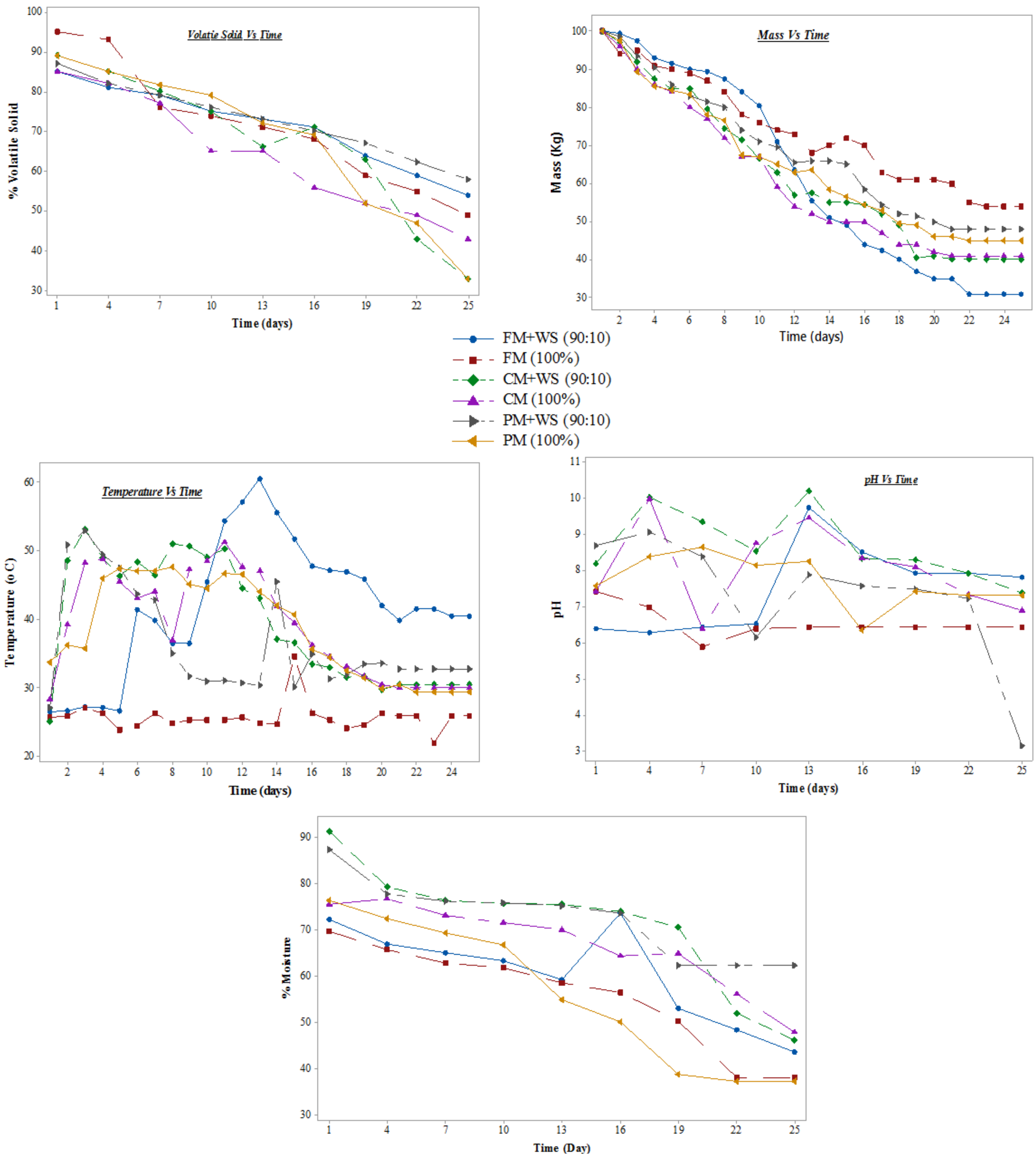

Figure 3. Time series graph of physiochemical properties for raw and amended livestock manure during windrow composting.

non-livestock manures (Rich et al., 2018).

There was a general decrease in mass and volatile solids by about 40 and 30%, respectively (Table 3). This decrease is been accounted for by moisture loss during aeration, breakdown of structural organic components and the mineralization of organic matter to form CO_2 and

Table 2. T-test results for comparison of means of physiochemical properties between raw livestock manure and raw livestock manure when amended with wood shavings under windrow composting.

Variable	VS (n=9)	Mass (n=25)	Temperature (n=25)	pH (n=9)
FM+WS and FM	t= 0.06 P = 0.955	t = -4.32 P = 0.000	t = 8.14 P = 0.000	t = 2.10 P =0.069
CM+WS and CM	t = 1.29 P = 0.232	t = 3.51 P = 0.002	t = 0.83 P = 0.415	t = 1.98 P = 0.083
PM+WS and PM	t = 1.49 P =0.176	t = 7.96 P = 0.000	t = -1.21 P = 0.239	t = -0.74 P = 0.478

Table 3. ANOVA table on the comparison of different livestock manure.

Mass		Temperature		pH		Volatile solid	
Factor	Mean	Factor	Mean	Factor	Mean	Factor	Mean
PM+WS	67.86 A	FM+WS	41.88 A	CM+WS	8.69 A	PM+WS	72.70 A
CM+WS	62.52 A	CM+WS	39.65 AB	FM+WS	7.82 AB	FM+WS	71.22 A
FM+WS	62.42 A	PM+WS	37.13 B	PM+WS	7.29 B	CM+WS	67.22 A

Table 4. Comparing the results of this study with other literatures.

Literature	pH	Volatile solid	Temperature	Moisture content
Mayur et al. (2019)	✓			
Rich et al. (2018)	✓			
Varma et al. (2014)		✓		
Bertoldi et al. (1983)				✓
Adhikari et al. (2009)			✓	
Trautmann et al. (1996)			✓	

H_2O during de-composition. Comparing physiochemical parameters of this present studies with literature (Table 4), shows that compost produced were optimal for utilization given that it meets all the ranges of the parameter after the 25th day.

CONCLUSION AND RECOMMENDATION

When comparing different livestock manure amended to its corresponding raw manure during windrow composting shows that, there was an insignificant decrease of TOC and VS and a significant mass reduction. Similarly, there was a significant temperature change in FM+WS and FM and, an insignificant different temperature change in CM+WS and CM and PM+WS and PM.

Secondly, comparing only amended livestock manures with wood shavings during windrow composting shows that, in all the amended livestock manure combinations, only temperature and pH had a significant change while mass and VS had an insignificant change. Hence, regular mixing on calculated wood shavings addition (waste ‘90’: wood shavings ‘10’ maintaining appropriate moisture content) should be applied to local domestic dumpsite since it reduces GHG concentrations, improves on the physiochemical parameters and arrests leachate preventing ground water pollution, increases food security and reduces air pollution.

Given that the current study signified the scope of additives aided composting process, hence, it is recommended that co-composting of livestock manure with woods shavings should be promoted since it enhances some physiochemical properties and strongly encourage to compost different combination of livestock/

wood shavings.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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