International Annals of Science
ISSN: 2456-7132
Volume 9, Issue 1, pp. 100-110, 2020
DOI: https://doi.org/10.21467/ias.9.1.100-110

RESEARCH ARTICLE

# Evaluation of Wood Ash as Additive for Cow Manure Composting

Blaise Pascal Bougnom[1], Dieudonne Onguene[2*], Alain Martial. Sontsa-Donhoung[1]

[1] Department of Microbiology, Faculty of Science, University of Yaounde I, Yaounde, Cameroon
[2] Department of Biochemistry, Faculty of Science, University of Yaounde I, Yaounde, Cameroon

* Corresponding author email: onguened@gmail.com

Received: 31 October 2019 / Revised: 11 December 2019 / Accepted: 07 March 2020 / Published: 09 March 2020

## ABSTRACT

This study was conducted to produce high-quality compost using both cow manure and wood ash that can specifically be used to increase the fertility of soils in tropical regions. Increased proportions of wood ash were co-composted with cow manure. During composting, the composts produced presented the classical composting temperature curve and attain a thermophilic composting phase (about 60 °C). After 117 days of composting, the produced composts (CMA 0%; CMA 5%; CMA 10% and CMA15%) had a C/N ratio between 16 and 30, and their pH, was basic, indicating maturity. They were rich in minerals (Mg; Ca; K+; and Na+) and poor in heavy metals (Zn; Cu and Pb). Wood ash addition raise the fungal communities except for CMA 0% and did not impair significantly on bacteria communities; however, addition of high amounts of wood ash could reduce the metabolism of the microbial communities including cellulase activity that showed a proportional decrease according to the added amount except for CMA 15%. The composts showed a germination index greater than 80% at all concentrations, indicating the absence of phytotoxicity. Therefore, co-composting of cow manure with wood ash (<15%) allowed to obtain a good organic fertilizer with higher liming potential, nutrient content, and less hazardous material which could be used in farms to remediate acidity of tropical soils.

**Keyword:** composting, cow manure, wood ashes, phytotoxicity, Tropical agriculture.

## 1 Introduction

To maintain human life agricultural production is essential. Sustainable agriculture must be able to improve soil fertility, which is important for future generations; but the choice of agricultural inputs to maintain soil fertility while respecting the environment is often disputed [1]. Intensive agriculture is based on the use of large quantities of pesticides and herbicides to increase yields, but the price to pay is the deterioration of the quality of soil, water, the environment, pollution and the emergence of new pathogens that are increasingly resistant to pesticides. The overuse of chemical fertilizers is a threat to human health, through the consumption of chemical residues that enter the food chain, as well as the inhalation of toxic gases [2]. Sustainability issues in modern agriculture are becoming increasingly important, reflecting the need for long-term soil fertility management and environmental protection. A sustainable agricultural system is in balance with the maintenance of the level of natural resources. [1]-[3]. Composting is a microbiological biodegradation process during which bio-waste is transformed into carbon dioxide, inorganic salts and humid substances, and heat is generated resulting from the metabolic activity of microorganisms [4]-[5]-[6]. Composting raw materials consist mainly of plant residues and relatively few remains of animals or minerals [7]. The resulting composts contain organic compounds precursors of humus and fertilizers, by their content of nutrients [8]-[9]-[11]. Compost thus makes it possible to fill the deficit of over-exploited soils and to improve their long-term fertility. The goal of composting is the production of stable products that can be conserved without further treatment and that can

be applied to soils without causing crop damage, but which on the contrary improve soil fertility and plant health [6]-[10]. The decline in soil fertility as a result of over-intensive or inappropriate agriculture is observed in both industrialized and developing countries. This results in a loss of stable organic matter in soils and an increased susceptibility of plants to diseases, due to the microbiological imbalance of soils [6]. Various countries are facing a significant increase in waste [4], however, much of this waste is organic in nature, and recycling through composting would make up for the moisture deficit of overexploited soils and reactivate a balanced microbiological life [5]-[6]-[7]. Urban municipalities in general and large metropolises in Africa are struggling to evacuate and treat their urban waste. Composting can be used to cope with the management of these wastes and the deterioration of the environment.

Co-composting Cow manure with wood ash as an additive could result in a nutrient rich compost with higher liming potential and less potentially toxic elements such as heavy metals. It is environmentally safe, cost effective, efficient, economically viable and ecologically sound. That is of relevance in relation to the management of soil fertility by resource-poor, subsistence farmers in the tropics where acid soil infertility is often a major limitation to crop production, whilst lime, fertiliser P and N, as well as other chemical fertilisers and agrochemicals are expensive.

The aim of this study consist of using both wood ash and cow manure to produce good composts by using proportional amounts of wood ash and cow manure to produce a good fertiliser, and by optimizing the proportion of the wood ash to be mixed up with cow manure in order to get best quality compost with higher liming potential, nutrient content, and less hazardous material.

## 2 Materials and Methods

### 2.1 Properties of input materials

For comparative purposes, four (4) types of compost in proportion of 0, 5, 10 and 15% wood ash/ cow manure (w/w) were produced, labelled CMA 0%, CMA 5%, CMA 10% and CMA 15% respectively. Cow manure used for the production of compost was obtained at the municipal slaughterhouse in Yaounde, wood ash (bottom ash) was collected at a wood incineration plant in Yaounde, Cameroon. Physical and chemical analysis of the input materials (wood ash and cow manure) are reported in Table 1.

### 2.2 Online monitoring of the composting

Composting was carried out in composting bins of 10 litres for 4 months. The experiment was a randomized block design with three replicates. Temperature and $CO_2$ evolution was measured weekly for the whole composting period [12]. The bins were wrapped with plastic tilt to prevent excessive heat loss during composting. Additional holes were cut around the bins to provide improved aeration and piles were turned once a month in order to ensure adequate $O_2$ levels inside piles. Temperature was monitored at a depth of 15 cm inside the piles at 10:00 h twice a week. The water content of piles was maintained at 60% of their water holding capacity throughout the 4-months experiment and water was added once a month, if necessary, after piles were turned. At the end of the composting process, measurements of the different physical, chemical and biological parameters of the produced composts was carried out. Moisture content was determined by weight loss at 105 °C [9]. Three subsamples were taken randomly from within each pile, they were bulked and homogenised. Part of each sample was stored at 4 °C for biological analysis and the rest was air-dried and stored for physical and chemical analysis.

### 2.3 Physical, chemical and biological analysis

Nutrients (P, K, Ca, Mg, and Na) and heavy metal (Pb, Cu, and Zn) contents were determined after wet digestion by inductively coupled plasma atomic emission spectroscopy (ICP-AES). The pH measurement was carried out according to the international standard ISO 10390 (1994). 10 g of compost were weighed and introduced into an Erlenmeyer flask containing 50 ml of distilled water; then the mixture was stirred for 5 minutes and then allowed to stand for 2 hours. After

standing, the pH was then measured using a HQ 11D brand pH meter.

To measure electrical conductivity**,** 20 g of compost were introduced into 100 ml of distilled water, stirred for 30 minutes and then filtered. The specific electrical conductivity of the filtered extract was measured using a Hach HQ conductivity meter 14d. (NF ISO 11265, 2005)

The methods below were used to determine an Organic C (Corg) and total N.

50 g of compost were dried in an oven at 105 °C and then calcined at 550 °C for 2 hours in an oven. The percentage of total organic matter (% MOT) or of volatile solid was obtained by difference in weighing between the mass of the sample dried at 105 °C and the mass of the sample after calcination [10] according to this formula:

$$\% MOT = \frac{M1 - M2}{M1} \; x \; 100$$

M 1: mass of the sample after heating in the oven (g);

M 2: mass of the sample after calcination (g);

-% MOT: percentage of dry matter content in the sample.

Total organic carbon was determined according to the formula of below:

$$\% C = \frac{\% \text{ MOT}}{2}$$

The total organic nitrogen content was determined by the Kjeldahl method. The mineralized sample is distilled with 40% sodium hydroxide in a BUCHI K-350 nitrogen distiller. The nitrogen vapors obtained are collected in an Erlenmeyer flask containing a pinkish color mixture composed of 20 ml of 3% boric acid and 3 drops of Tashiro reagent. This mixture gradually turns yellowish-green in the case where the distilled sample contains nitrogen, as the sample drops from the distillation column are added. The solution obtained is assayed by titrimetry with 0.1 N sulfuric acid.

The C / N ratio of the composts was calculated from the organic carbon and nitrogen values obtained. It was determined according to the formula below:

$$C/N = \frac{percentage\ of\ organic\ carbon}{percentage\ of\ total\ nitrogen}$$

## 2.4 Microbiological analysis

The analysis of mycoflora was carried out according to the suspensions-dilutions technique [12], on medium agar Potato dextrose agar (PDA) added to an antibiotic (Gentamicin). In a 250 ml Erlenmeyer flask containing 90 ml of distilled water sterile, 10 g of dry compost are added aseptically (after drying at 30 °C overnight). This mixture is stirred mechanically with magnetic bars for 30 minutes to suspend the compost particles and the spores and mycelia attached thereto. The suspension obtained corresponds to the $10^{-1}$ dilution. 1 ml of the $10^{-1}$ dilution is removed aseptically and put in 9 ml of sterile distilled water thus giving the $10^{-2}$ dilution which is stirred for two minutes before taking 1 ml which is added to 9 ml of water sterile distilled and so on until dilution $10^{-8}$. 0.1 ml is taken from each dilution, operating from $10^{-8}$ dilution to the $10^{-1}$ dilution, and seeded onto the culture media, using a sterile glass bent pipette. Petri dishes was incubated at 26 ° C for 3 days. The fungal load was determined by colony counting and the results were expressed in CFU (Colony Forming Units) / g of compost according to the mathematical formula below.

$$N = \frac{\Sigma \text{ colonies}}{Vml\ x(n1 + 0.1\ n2)}\ x\ d1$$

N: Number of CFU per gram of compost; Σ colonies: Sum of colonies of interpretable petri dishes; V: Volume of solution deposited (1ml); n1: Number of petri dishes considered at the first dilution retained; n2: Number of petri dishes considered at the second dilution retained; d1: Factor of the first dilution retained.

Only Petri dishes containing between 15 and 150 colonies at two successive dilutions were selected for enumeration [12]- [13].

The determination of the total bacterial flora was carried out according to the technique of suspensions-dilutions on solid medium, nutrient agar added to an antifungal agent: 0.5% nystatin. 5 g of each compost were placed in a 100 ml Erlenmeyer flask containing 45 ml of sterile physiological saline (9 g of NaCl / L of distilled water) and suspended with a magnetic stirrer for

30 minutes. The suspension is then decanted for 20 minutes, then the supernatant is removed, and it constitutes the $10^{-1}$ dilution. From this suspension, decimal dilutions are made up to $10^{-8}$. 0.1 ml is taken from each dilution, operating from $10^{-8}$ dilution to $10^{-1}$ dilution, and seeded onto the culture media, using a sterile glass bent pipette. The petri dishes are incubated at 30 °C. for 24 hours [12].

### 2.5 Enzyme assays

To determine cellulase activity, 5 g compost was placed in a 50-ml Erlenmeyer flask and incubated with 0.5 ml toluene and 20 ml buffered 2% carboxymethyl cellulose (CMC) at 30°C for 24 h. After incubation, the suspension was mixed well and centrifuged three times at 17,390g for 10 min. A portion (10ml) of the supernatant was transferred into a 50-ml plastic centrifuge tube and treated with K-saturated cation-exchange resin (2 g). The mixture was shaken for 30min, and the supernatant was analyzed for reducing sugars by the Somogyi-Nelson method [14]-[15]. The blue solutions developed for the compost extracts obtained from the CMC-treated compost were centrifuged once as described above before color measurement at 710 nm. Two controls were performed. One was buffered 2% CMC incubated with 0.5 ml of toluene but without compost, and the other was 5 g of compost sample incubated with 0.5 ml of toluene and 20 ml of acetate buffer without CMC. After incubation, the mixtures were treated as previously described. The values of the two controls were subtracted from the glucose values obtained for the CMC-treated compost.

In order to determine proteases activity, extracts were prepared by shaking (120 osc./min; 3.5 cm stroke length) dried composts with 0.1 M Tris-borate buffer, pH 8.1 (5 ml buffer/g compost) at 40°C for 60 rain, then centrifuging for 30 rain at 2,000 g. The extraction procedure was repeated at least twice before determining the residual protease activities of extracted composts.

The assays were based on the rate of release of leucine from benzyloxycarbonyl (Z-) phenylalanyl leucine in 0.1 M Tris-borate buffer, pH 8.1. Conditions of assay were as described earlier [16] except that the amount of added substrate was halved and, in later assays, using extracts only, the reaction mixtures were incubated without shaking at 50 °C. All activities were corrected for those of controls without substrate and were expressed as/~moles of leucine released/hr/g dry weight of compost

### 2.6 Phytotoxicity test

To evaluate the compost maturity and their phytotoxicity, a germination assay was conducted with corn seeds and the Germination Index (GI) was determined according to [5]-[17]. The germination test was carried out (in triplicate) on filter paper in petri dishes. Ten corn seeds were placed onto filter paper, two millilitres of aqueous extract (1/10 W/V) from composts was added to dishes and the dishes were placed in the dark at 25 °C. Petri dishes with corn seeds and sterile distilled water was the control.

The germination percentages with respect to control and root lengths were determined after 6 days. The GI was calculated as GI = %G × Le/Lc, where %G is the percentage of germinated seeds in each extract with respect to control, Le is the mean total root length of the germinated seeds in each extract and Lc is the mean root length of the control. The control GI value is considered as 100%.

### 2.7 Statistical analyses

The data obtained were subjected to a two-way analysis of variance (ANOVA) followed by a Tukey's B-test at 5% level. The data were analysed using SPSS Software Package 16.

## 3 Results

### 3.1 Material characteristics

The physical, chemical properties and the micronutrients content of the Cow manure and wood ash are reported in Table 1. pH was slightly higher in Wood ash than in Cow manure, while EC were higher in Cow manure. C and N were respectively higher in Wood ash and slightly higher in Cow manure. Concentrations were: Zn, 0.06 and 0.30 mg.kg-1; Cu, 1, 71 and 2.13 mg.kg-1; Pb, 0,50 and 24,5 mg.kg-1 for cow manure and wood ash respectively.

***Table 1:*** *Physical and chemical properties of the cow manure and wood ash used.*

| Parameters | Cow manure | Wood ash |
|---|---|---|
| pH (water) | 8,98 | 9,79 |
| EC (mScm$^{-1}$) | 5000 | 4880 |
| C (gkg$^{-1}$) | 80 | 95 |
| Ntotal(gkg$^{-1}$) | 2.50 | 3 |
| P (g.kg$^{-1}$) | 0,50 | 0,60 |
| Mg2+ (g.kg$^{-1}$) | 0.07 | 0,02 |
| Ca2+ (g.kg$^{-1}$) | 0.32 | 0,28 |
| K+ (g.kg$^{-1}$) | 4 | 1 |
| Na+ (g.kg$^{-1}$) | 13 | 1,30 |
| Pb (mg.kg$^{-1}$) | 0,54 | 24,5 |
| Zn (mg.kg$^{-1}$) | 0,06 | 0,30 |
| Cu (mg.kg$^{-1}$) | 1.71 | 2,13 |

## 3.2 Composting temperature

The variations of temperature during composting are shown in Figure. 1. The temperature dynamic was similar in all the composting bins. At the beginning of the process, the temperature of the composting bins was the ambient temperature, and then the temperature increased. The heating period was between day 28 and day 49. After that, all the compost bins reached the ambient temperature. The temperature peak was about 60 °C.

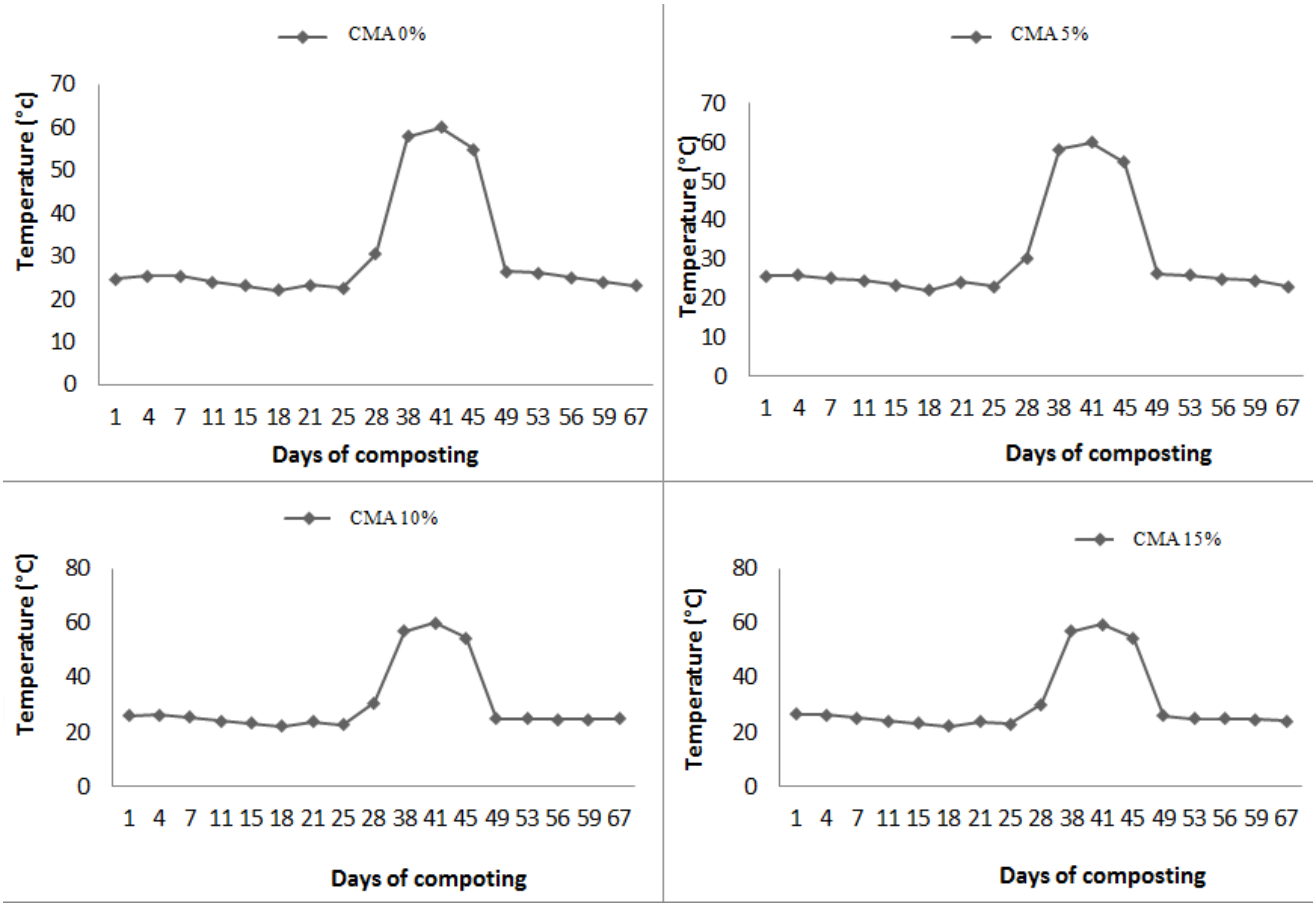


***Figure 1:*** *Temperature during composting of cow manure-based composts made with increasing percentages of added wood ash. CMA 0%=100% cow manure, CMA 5%= 95% cow manure /5% wood ash, CMA 10%=90% cow manure /10% wood ash, CMA 15%=85% cow manure /15% wood ash.*

***Table 2**: pH, EC, C, N, C/N, and P of the produced composts made with increasing percentages of added wood ash.*

| Treatment | pH (Water) | EC (mS/cm) | P (mg/kg) | C (g/kg) | N (g/kg) | C/N |
|---|---|---|---|---|---|---|
| CMA 0% | 9.04 | 6160 ± 240,41[a] | 0,30 ± 0,28[a] | 31 ± 17,64 [a] | 1,9 ± 0,12 [a] | 16,3 ± 9,28[a] |
| CMA 5% | 9.13 | 5995 ± 205,06[a] | 0,37 ± 0,10[a] | 38 ± 21,63 [a] | 2,1 ± 0,14 [a] | 18,0 ± 8,10[a] |
| CMA 10% | 9.15 | 6170 ± 84,85[a] | 0,41 ± 0,37 [a] | 31,5 ± 17,93 [a] | 1,8 ± 0,12 [a] | 17,5 ± 9,40[a] |
| CMA 15% | 9.15 | 6770 ± 353,55[a] | 0,27 ± 0,24[a] | 34,1 ± 19,41 [a] | 2 ± 0,13 [a] | 17,0 ± 9,67[a] |

Means followed by the same letter in a column are not significantly different at P ≤ 0.05

***Table 3:** Extractable nutrients and heavy metal content of the produced composts made with increasing percentages of added wood ash.*

| Treatment | Exchangeable cations (mg.kg-1) | | | | Heavy metal (mg.kg-1) | | |
|---|---|---|---|---|---|---|---|
| | Mg | Ca | K | Na | Pb | Zn | Cu |
| CMA 0% | 0,03 ± 0,01 [a] | 0,39 ± 0,07[a] | 0,06 ± 0,01[a] | 6,50 ± 4,59[a] | 0.8±12 [b] | 0,0450 ± 0,04[a] | 2,11 ± 1,01[a] |
| CMA 5% | 0,08 ± 0,01[a] | 0,22 ± 0,02[a] | 0,06 ± 0,01[a] | 13,00 ± 1,31[a] | 18.6±1.4 [a] | 0,20 ± 0,09[a] | 2,22 ± 1,20[a] |
| CMA 10% | 0,04 ± 0,02[a] | 0,25 ± 0,07[a] | 0,00 ± 0,00[a] | 11,50 ± 2,26[a] | 20.1±2.5 [a] | 0,02 ± 0,01[a] | 1,78 ± 0,55[a] |
| CMA 15% | 0,07 ± 0,01[a] | 0,45 ± 0,15[a] | 0,00 ± 0,00[a] | 6,50 ± 4,59[a] | 25.1±3.9 [a] | 0,07 ± 0,007[a] | 1,55 ± 0,21[a] |

Means followed by the same letter in a column are not significantly different at P ≤ 0.05.

### 3.3 Physical and chemical properties

The physical and chemical properties and the micronutrients content of the produced composts are reported in Table 2 and 3.

At the end of the composting, the pH of CMA 0%, CMA 5%, CMA 10% and CMA 15% was 9.04; 9.13; 9.15, and 9.15, respectively. Wood ash additive increased the pH in CMA 10% and CMA 15%. EC did not significantly change among the different composts. Wood ash addition did not have significant impact on concentrations of C, N, and the C/N ratio (Table 2).

Concentration of exchangeable cations Mg, Ca and Na fluctuated among the different composts, with no significant difference (Table 3). The concentration of K was constant in CMA 0% and CMA 5%, and decreased significantly in CMA 10% and CMA 15%. Regarding heavy metals, concentration of Pb increased in amended composts. The concentrations of Zn fluctuated without significant difference and those of Cu decreased significantly in CMA 10% and CMA 15% (Table 3).

### 3.4 Biological properties

Wood ash addition had respectively a positive impact on fungal and a negative impact in bacterial population, respectively in CMA 5% and CMA 10%. The fungal biomass was higher in CMA 15%; and the bacterial biomass was higher in CMA 0% and CMA 15%, respectively (Table 4).

***Table 4**: Microbial biomass counted in compost samples.*

| Treatment | Microbiail biomass (.105 UFC.g-1 compost) | |
|---|---|---|
| | Bacteria | Fungi |
| CMA 0% | 603,64 ± 4,29[b] | 474,86 ± 5,47[a] |
| CMA 5% | 462,54± 2,88[a] | 536,04± 2,14[a] |
| CMA 10% | 346,23±8,27[a] | 635,15± 0,95[b] |
| CMA 15% | 562,49±3,24[b] | 779,3± 1,41[b] |

Means followed by the same letter in a column are not significantly different at P ≤ 0.05.

Wood ash addition did not impair protease activities since the difference were not significant between amended and not amended compost. Cellulase activity was greater than protease activity for the different composts; in addition,

the increasing of wood ash addition seems to inhibit cellulase activity (Table 5).

***Table 5:*** *Enzyme activities in Cow manure -based composts made with increasing percentages of added wood ash.*

| Treatment | (U/mg compost.h$^{-1}$) | |
|---|---|---|
| | Cellulase activity | Protease activity |
| CMA 0% | 20,79 ± 3,21$^{a}$ | 1,37 ± 0,45$^{a}$ |
| CMA 5% | 17,71 ± 4,48$^{b}$ | 1,05 ± 0,21$^{a}$ |
| CMA 10% | 17,51 ± 2,55$^{b}$ | 1,23 ± 0,47$^{a}$ |
| CMA 15% | 12,17 ± 3,01$^{c}$ | 1,38 ± 0,16$^{a}$ |

Means followed by the same letter in a column are not significantly different at $P \leq 0.05$.

### 3.5 Germination index

Wood ash addition was not toxic to the seeds and seedlings at the concentration of 10% 30% and 50%. All extracts, CMA 0%, CMA 5%, CMA 10%, and CMA 15%, had a germination index between 80% to 83.52% (Figure 2).

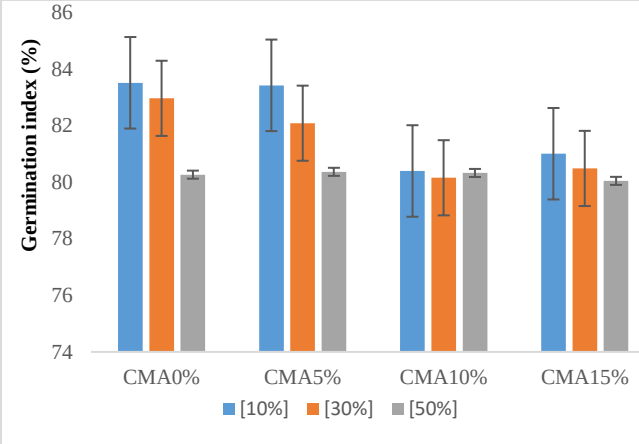


***Figure 2****: Germination index in cow manure-based composts made with increasing percentages of added wood ash. Means followed by the same letter are not significantly different at P ≤ 0.05.*

## 4 Discussion

### 4.1 Composting process

All treatments' temperatures followed the typical evolution of composting processes, that is, heating phase, thermophilic phase, cooling phase, and mature phase (Figure 1). The evolution of the temperature during the composting process showed a time of stabilization before the process really begins. The fluctuation of this one was similar to the external environment temperature, and that is in agreement with the work of [18], which showed that at the beginning of the composting process, the temperature of the compost merges with the room temperature (25 °C).

From the eighteenth day (temperatures between 22 °C and 22.16 °C, the process really began in each treatment. This is in accordance with the theoretical curve of temperature evolution obtained by [18], and the one obtained during the composting of a manure of cattle by [19], in with the composting process began below 20 °C.

The addition of wood ash did not impact the composting process because the temperature variation curves of the different treatments (CMA 0%, CMA 5%, CMA 10% and CMA 15%) presented four phases and that is in agreement with the work of [20]:

during a slight mesophilic phase between the eighteenth day and the twenty-eighth day, the temperature in all treatments quickly reach 30-30.6 °C. The heat may be generated by the intensive microbial activities and the appropriate C/N due to the addition of wood ash necessary for the development of microorganisms [20]. In this initial phase, the development of the mesophilic microorganisms was the result of the rapid and easy biodegradation of the organic matter (free amino acids), [21]. And this generated heat production and thus raises the temperature of the compost.

A thermophilic phase between the 28th day (30 °C) and the 41st day (60 °C) might be the result of the intensive microbial activities and the appropriate C/N [20**],** and were probably due to the addition of wood ash, which act by regulating the free air space within the cow manure, and might be due to the first time when the treatments were turned [22]. That thermophilic phase is also in agreement with the thermophilic phase of the theoretical curve of [18], where the temperature of the thermophilic phase is up to 70 °C.

The production of heat during the thermophilic phase may be due to the microorganisms' activities, which is proportional to the oxygen availability in each treatment [23], and in this work, the experiment was done in small buckets

of 10 liters (contents: 3kg). During this phase, we have the presence of an activity of fungi and thermophilic bacteria allowing the rise in temperature, responsible for the destruction of pathogens [17]-[24]-[18]. The presence of a single thermophilic phase during this process, may be explained by the fact that all treatments were homogeneous (consisting mainly of cow manure and ash). Moreover, the cow manure had already undergone a partial degradation (mechanical and intestinal) by the cow.

A cooling phase that, which is in accordance with the word done by [17] goes from the 41st to the 49th day was observed, and the temperature decreases from 60 °C to 26 °C.

During this phase, the medium is colonized again by mesophilic microorganisms. They degrade polymers that remain intact in the thermophilic phase and incorporate nitrogen into complex molecules. It ends with the return to room temperature [19].

A maturation phase starts from the 49th day (temperature equal to 25 °C). During this phase, the temperatures of the treatments were confused with the ambient temperature [5] which showed that there was no longer any significant activity of the microorganisms. During this phase, precursors of humus and slow degradation of resistant compounds slowly appear [3], resulting in a dark brown to black coloration of the compost and making it thinner and more homogeneous [25]-[26]. Its texture was similar to the soil's texture. At the same time, as well as the organic matter was degraded, the pH of the medium also increased.

The pH of the two initial substrates, cow dung (8.98) and wood ash (9.79), were lower than the pH of the different composts. This is in agreement with the work of [27]-[28], who showed that the initial waste has a slightly higher acidity than the finished composts. This may be explained by the presence of a thermophilic phase in which there is the degradation of organic acids (produced during acidophilic phase) that allows a phenomenon of alkalization of the compost, which is increased by the mineralization of the soil's nitrogen. The increase in pH may be attributed to the lack of production of some organic acids. It may also result to the lack of $CO_2$ mineralization of organic material [29]. The high pH trends observed for composts might be also correlated with the quantities of the wood ash added. [1]-[3]

Humidity levels of composts CMA 15%; CMA 10% and CMA 5% are higher than the humidity of CMA 0%. This might be explained by the fact that during composting there is a degradation of the organic matter during which water is produced ($H_2O$), and water is more mobilized by the wood ash. It might also depend on the waste typology [23].

EC value of compost is an important parameter for determining compost quality and potential hazards to plants because a high salt concentration in the soil will result in land degradation [18] and reflects a potential phytotoxicity. The increase in EC in composts compared to the initial compounds may be explained by the mineralization of organic matter during the process [4] [27]-[28]. It may also be related to the maturation process of composts [18]-[5] during which organic acids and soluble salts are released during the decomposition of organic matter, [30]-[31], and also due to the lowest concentrations of exchangeable bases in the medium , ($Mg^{2+}$, $Ca^{2+}$, $K^+$ and $Na^+$) which are usually responsible for the salinity [32]-[33]. The increase of EC might be also due to the fact that wood ash has high electrical conductivity [34]; as a result, ash addition might increase the salinity of the final product [34]. An excessively high EC in compost is harmful for the plant growth, since it causes osmotic problems and affects water intake ability [17]-[18]. Although the EC value of this study increased, it has met the suitable EC that marks compost maturity [18.].

Decreases in nitrogen and organic carbon concentration are due to the utilization of the organic substances by microorganisms which are essential for their metabolism, leading to the mineralization of C to $CO_2$. On the other hand, it is also the result of the volatilization of $NH_3$ or $N_2O$ during the composting process. The C/N ratio is an important indicator of compost maturity. The C / N ratios of the starting substrates also significantly decreased at the end of the composting process. It might result to the lack of nitrogen volatilisation (i.e. increasing

nitrogen content) [18]. This decrease may be also due to the release of the carbon in the form of $CO_2$, and it would imply the degree of humification of the organic matter [18]. Previous studies have indicated that a C/N ratio of between 10 and 21 at the end of composting is an indicator of compost maturity [18], the composts produced meet this criterion.

The variations or the decrease of P in the different composts may be due to the fact that the composting may affect the distribution of P fractions, and the lack of phosphate solubilizing microbes that might solubilize insoluble P composts. It could also result to the lower presence of microbial activity related to organic acids production lead to the solubilization of precipitated inorganic P [35].

Ash metal contents are reported to be among the most relevant aspects that may negatively affect the final compost quality [34]. However, the environmental impact related to the wood ash utilisation as compost additive is expected to be low. Furthermore, the wood ash-amended composts obtained in the above-mentioned studies had metal contents lower than the limits set by the related regulations [32]-[34]. Therefore, as far as the metal presence is concerned it may conclude that the use of wood ash-amended compost should not represent a detriment for plant growth or an environmental risk, provided that wood ash is added according to well-balanced amounts [33]. The low concentrations of metals in composts would be justified by their low content in cow manure and wood ash. The slight increase in Pb in wood ash composts could be explained by the ash additive. Limit values of Zn; Cu and Pb prescribed by NF U 44-051, 2006 are respectively 600 mg / kg, 300 mg / kg and 180 mg / kg respectively, the values present in these composts are well below this recommendation.

### 4.2 Phytotoxicity evaluation

The value of the GI is one of the most commonly used and sensitive biological indicators for assessing the phytotoxicity and maturity of compost products [5]. The results obtained from the phytotoxicity test show that the composts had GIs ≥ 80% and would therefore be mature and devoid of any toxic effect. GI values of 80% are indicative of mature compost with no phyto-toxic effect [17]-[36]-[37]-[17]-[38]

### 4.3 Microbial parameters

Wood ash admixture had respectively negative and positive effects on bacterial and fungal populations. This could be explained by the research run by [3], which holds that fungi are more able to metabolize wood ash than bacteria. It might also depend on the temperature, humidity, presence of nutrients and environment parameters during the composting [39] Therefore the important presence of this total microflora would testify the maturity and eco- compatibility of the composts. That negative and positive effects could also be explained by the increase of EC. As reported by [40] fungal are more sensitive than bacterial to high salt concentrations [7]-[17]. Cellulases are secreted by various cellulolytic microorganisms developed on composting materials [41]. The relative drop in cellulase activity might be due to the fact that in the later phase of composting there was not lots of celluloses, which are complex substances that are usually degraded in the later phase of composting and therefore usually caused the higher production of cellulases in the later phase. [41]. It may also be the consequence of the addition of wood ash in composts. This is in accordance with the work of [42], who reported that enzymatic activities of cellulases decreased with the addition of wood ash in composts. Therefore, the cellulase activity is the result of the action of fungi [43], and the protease activity is the consequence of the action of fungi and bacteria, [14]-[45].

## 5 Conclusion

Co-composting of cow manure with wood ash permitted to produce composts with higher pH conferring higher buffering capacity, thus reducing the quantity of organic fertilisers needed to deal with soil acidity. The composts are rich in micronutrients and macronutrients content, and low in heavy metals. The composts are not phyto-toxic. Wood ash admixture did not have a significant impact on the number of the bacteria, the wood ash had a positive effect on the fungal community, but nevertheless, their cellulase and

protease activities could be negatively impacted if the concentrations of ash added are high. Therefore, composts produced from a mixture of cow manure and wood ash meet the quality criteria for organic amendments and can be used in agriculture in order to remediate soil acidity and base deficiency and boost the soil microbial pool in tropical agricultural soils. Additional studies are needed to evaluate the produced composts if they can be used to fight against plant diseases.

## 6 Declarations

### 6.1 Acknowledgements

The authors thank Yannick AWONO for supplying the wood ash, the Agricultural Research Institute for Development (IRAD) Cameroon for assistance with the chemical analysis.

### 6.2 Competing Interests

The authors declared that no conflict of interest exist in this publication.

### How to Cite this Article:

B. P. Bougnom, O. Dieudonne, and A. M. Sontsa-Donhoung, “Evaluation of Wood Ash as Additive for Cow Manure Composting”, *Int. Ann. Sci.*, vol. 9, no. 1, pp. 100-110, Mar. 2020. doi: 10.21467/ias.9.1.100-110

### References

[1] D. Neher, "Ecological sustainability in agricultural systems: definition and measurement," Integrating sustainable agriculture, ecology, and environmental policy. Routledge, pp. 51-61 May, 2018.

[2] J. J. Steffan, R. Sharma, T. Parween, and P.k. Patanjali, "The effect of soil on human health: an overview." *European journal of soil science*, vol 69, no.1, pp.159-171, 2018.

[3] A. Cerda, A. Artola, X. Font, R. Barrena, T. Gea and A. Sánchez. "Composting of food wastes: Status and challenges", *Bioresource Technology*, vol. 248, no.1, pp. 57-67, 2018.

[4] A. Muscolo, T. Papalia, G. Settineri, C. Mallamaci and A. Jeske-Kaczanowska. "Are raw materials or composting conditions and time that most influence the maturity and/or quality of composts? Comparison of obtained composts on soil properties." *Journal of cleaner production vol.*195, no. 10, pp. 93-101, Sep 2018.

[5] J. Bohacz, "Composts and Water Extracts of Lignocellulosic Composts in the Aspect of Fertilization, Humus-Forming, Sanitary, Phytosanitary and Phytotoxicity Value Assessment." *Waste and Biomass Valorization* vol.10, no.1, pp.2837-2850, Oct, 2018.

[6] B. P. Bougnom, B. A. Knapp, D. Elhottová, A. Koubová, F. X. Etoa, H. Insam, "Designer compost with biomass ashes for ameliorating acid tropical soils: Effects on the soil microbiota." *Applied soil ecology*, vol. 45, no. 3, pp. 319-324, Jul, 2010.

[7] A. Muscolo, T. Papalia, G. Settineri, C. Mallamaci and A. Jeske-Kaczanowska, "Are raw materials or composting conditions and time that most influence the maturity and/or quality of composts? Comparison of obtained composts on soil properties", *Journal of cleaner production vol.*195, no. 10, pp. 93-101, Sep 2018.

[8] J. Bohacz, "Composts and Water Extracts of Lignocellulosic Composts in the Aspect of Fertilization, Humus-Forming, Sanitary, Phytosanitary and Phytotoxicity Value Assessment." *Waste and Biomass Valorization* vol.10, no.10, pp.2837-2850, Oct, 2018. doi:10.1007/s12649-018-0334-6

[9] J.G. Fuchs, U. Baier, A. Berner, J. Mayer, L.Tamm, and K. Schleiss, "Potential of different composts to improve soil fertility and plant health," *In ORBI: Biological Waste Management. From Local to Global; Proceedings of the International Conference ORBIT 2, Verlag ORBIT eV, Weimar*, pp. 507-517, 2006.

[10] J. M. Bremner, "Determination of nitrogen in soil by the Kjeldahl method," *The Journal of Agricultural Science*, vol. 55, no. 1, pp. 11-33, 1960.

[11] F. Freléchoux, B. Alexandre, F. Gillet, J. M. Gobat, and F. H. Schweingruber "Succession from bog pine (Pinus uncinata var. rotundata) to Norway spruce (Picea abies) stands in relation to anthropic factors in Les Saignolis bog, Jura Mountains, Switzerland," *Annals of Forest Science* , vol.60, no. 4, pp. 347-356, May, 2003.

[12]. M., G. W., & Funder, S. (1955). "Practical Mycology. Manual for Identification of Fungi". *Mycologia*, vol. 47, no.1, pp.153,1955.

[13] L. Zhang, J. Zhang, G. Zeng, H. Dong, Y. Chen, C. Huang, Y. Zhu, R. Xu, Y. Cheng, K. Hou and W. Cao. "Multivariate relationships between microbial communities and environmental variables during co-composting of sewage sludge and agricultural waste in the presence of PVP-AgNPs". *Bioresource technology*. no.1, vol. 261: pp.10-18, Aug 2018.

[14] M. A. Tabatabai, "Soil enzymes." *Methods of soil analysis: part 2—microbiological and biochemical properties methodsofsoilan* , vol. 2,pp.. 775-833, Jan. 1994.

[15] S.P. Deng, and M. A. Tabatabai. "Cellulase activity of soils." *Soil Biology and Biochemistry*, vol. 26, no. 10, pp. 1347-1354, Oct, 1994.

[16] J. N. Ladd, and J. H. A. Butler, "Short-term assays of soil proteolytic enzyme activities using proteins and dipeptide derivatives as substrates." *Soil Biology and Biochemistry*, vol. 4, no 1, p. 19-30. 1972.

[17] Liu, N., Hou, T., Yin, H., Han, L., & Huang, G, "Effects of amoxicillin on nitrogen transformation and bacterial community succession during aerobic composting", *Journal of Hazardous Materials.* vol. 362, pp. 258-265, Jan, 2019.

[18] L. Liu, S. Wang, X. Guo, T. Zhao, and B. Zhang, "Succession and diversity of microorganisms and their association with physicochemical properties during green waste thermophilic composting". *Waste Management*, vol. 73, no.1, pp. 101–112, Mar 2018.

[19] B. Godden, T. Legon, P. HELVENSTEIN, and M. Penninckx, "Regulation of the production of hemicellulolytic and cellulolytic enzymes by a Streptomyces sp. growing on lignocellulose," *Microbiology*, vol. 135, no. 2, pp.285-292, Feb, 1989.

[20] Y. Wei, D. Wu, D. Wei, Y. Zhao, J. Wu, X. Xie, Z. Wei, "Improved lignocellulose-degrading performance during straw composting from diverse sources with actinomycetes inoculation by regulating the key enzyme activities".*Bioresource Technology*. Vol.271, pp.66-74, Jan.2019.

[21] R. Cáceres, K. Malińska, and O. Marfà. "Nitrification within composting: A review". *Waste Management*, vol. 72, pp. 119–137, 2018.

[22] X. Z. Zhong, S.C. Ma, S.P.Wang, T.T.Wang, Z.Y.Sun, Y.Q. Tang, K. Kida, "A comparative study of composting the solid fraction of dairy manure with or without bulking material: Performance and microbial community dynamics". *Bioresource Technology*, vol. 247, pp. 443–452, 2018.

[23] J. Bohacz, "Microbial strategies and biochemical activity during lignocellulosic waste composting in relation to the occurring biothermal phases". *Journal of Environmental Management*, vol. 206, ,pp. 1052–1062. 2018.

[24] Z. Yu, J.Tang, H.Liao, X. Liu, P. Zhou, Z. Chen, S. Zhou, "The distinctive microbial community improves composting efficiency in a full-scale hyperthermophilic composting plant". *Bioresource Technology*, vol. 265, pp. 146–154, 2018.

[25] F. G. Ceglie, and H. M. Abdelrahman, "Ecological intensification through nutrients recycling and composting in organic farming," *Composting for Sustainable Agriculture*, *Springer, Cham*, pp. 1-22, 2014.

[26] B. Godden, M.J. Penninckx, and C. Castille, "On the use of biological and chemical indexes for determining agricultural compost maturity: extension to the field scale," *Agricultural Wastes* vol. 15, no. 3, pp. 169-178, Jan, 1986.

[27] J. H. Hsu, and S.L. Lo, S.L, "Chemical and spectroscopic analysis of organic matter transformations during composting of pig manure.," *Environmental Pollution*, vol. 104, no. 2, pp. 189-196, Feb, 1999.

[28] B. Gabrielle, J. Da-Silveira, S. Houot, and C. Francou,"Simulating urban waste compost effects on carbon and nitrogen dynamics using a biochemical index." *Journal of Environmental Quality*, vol. 33, no. 6, pp. 2333-2342, Nov, 2004.

[29] Z. Usmani, V. Kumar, R. Rani, R, P. Gupta, and A. Chandra "Changes in physico-chemical, microbiological and biochemical parameters during composting and vermicomposting of coal fly ash: a comparative study". *International Journal of Environmental Science and Technology*. Vol. 16, no.8, pp. 4647-4664. Aug, 2019.

[30] Y. Avnimelech, M. Bruner, L. Ezrony, R. Sela, and M. Kochba, "Stability indexes for municipal solid waste compost." *Compost Science and Utilization* vol. 4, no. 2, pp. 13-20, Mar, 1996.

[31] L. Wu, L. Q. Ma, and G. A. Martinez, "Comparison of methods for evaluating stability and maturity of biosolids compost," *Journal of Environmental Quality*, vol. 29, no. 2, pp. 424-429, 2000.

[32] B. P. Bougnom, and H. Insam, "Ash additives to compost affect soil microbial communities and apple seedling growth," *Die Bodenkultur*, vol.60, no.2, pp. 5-15, 2009.

[33] R. Mandelbaum, Y. Hadar, and Y. Chen, "Composting of agricultural wastes for their use as container media: effect of heat treatments on suppression of Pythium aphanidermatum and microbial activities in substrates containing compost," *Biological Wastes*, vol. 26, no. 4, pp. 261-274, Jan, 1988.

[34] B. P. Bougnom, and H. Insam, "Ash additives to compost affect soil microbial communities and apple seedling growth," *Die Bodenkultur*, vol.60, no.2, pp. 5-15, 2009.

[35] T. Eggen, and Q..Vethe. "Stability indices for different composts." *Compost Science and Utilization*, vol. 9, no. 1, pp. 19-26, Jan, 2001.

[36] T.H. DeLuca, and D. K. DeLuca, "Composting for feedlot manure management and soil quality." *Journal of Production Agriculture* vol. 10, no. 2, pp. 235-241, 1997.

[37] Luo, Y., Liang, J., Zeng, G., Chen, M., Mo, D., Li, G., & Zhang, D. (2018). "Seed germination test for toxicity evaluation of compost: Its roles, problems and prospects". *Waste Management*, vol. 71, pp.109–114, 2018.

[38] Jiang, J., Kang, K., Chen, D., & Liu, N, "Impacts of delayed addition of N-rich and acidic substrates on nitrogen loss and compost quality during pig manure composting". *Waste Management*, vol. 72, pp. 161–167, 2018.

[39] S.M. Tiquia, and N. F. Y. Tam, "Elimination of phytotoxicity during co-composting of spent pig-manure sawdust litter and pig sludge." *Bioresource Technology*, vol. 65, no. 1-2, pp. 43-49, Jul, 1998.

[40] C. Asquer, G. Cappai, A. Carucci, G.De Gioannis, A. Muntoni, M. Piredda, and D. Spiga, "Biomass ash characterisation for reuse as additive in composting process". *Biomass and Bioenergy*, vol. 123, pp. 186–194, 2019.

[41] Y. Wei, Y. Zhao, M. Shi, Z, Cao, Q. Lu, T. Yang, and Z. Wei, " Effect of organic acids production and bacterial community on the possible mechanism of phosphorus solubilization during composting with enriched phosphate-solubilizing bacteria inoculation". *Bioresource Technology*, vol. 247, pp.190–199, 2018.

[42] J. Du, Y. Zhang, M. Qu, Y. Yin, K. Fan, B. Hu, C. Ma, "Effects of biochar on the microbial activity and community structure during sewage sludge composting". *Bioresource Technology*. Vol. 272, no. 1, pp.171-179, Jan, 2019.

[43] O.N. Belyaeva, and R. J. Haynes, "Chemical, microbial and physical properties of manufactured soils produced by co-composting municipal green waste with coal fly ash," *Bioresource technology* , vol. 100, no. 21, pp. 5203-5209, Nov, 2009.

[44] S.M. Tiquia, H.C. Wan, and N.F. Tam, "Microbial population dynamics and enzyme activities during composting." *Compost science and utilization*, vol. 10, no. 2, pp. 150-161, Mar, 2002.

[45] A. J. McCarthy, "Lignocellulose-degrading actinomycetes." *FEMS Microbiology Reviews*, vol. 3, no. 2, pp. 145-163, Jun, 1987.