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Changes in chemical and biological properties during co-composting of swine dung and different plant materials

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Abstract

Plant residues and animal manures have been reported to have high nutritive value. This study was carried out to evaluate different plant materials in combination with swine dung for their chemical and biological properties. Eight (8) different plant materials namely banana leaves, cassava peels, *Giliricidia sepium*, *Leuceana*, Maize stover, Neem, *Panicum maximum* and saw dust was combined with swine dung in a ratio 1:1 and composted for a period of eight weeks using the enclosed heap method. Chemical and biological parameters were monitored at a two (2) week interval. Analysis of the plant materials before composting showed that *Giliricidia sepium* was the richest in N (3.63%), P (0.14%), K (2.59%), Mg (1.07%). Banana leaves was rich in Ca (4.75%) while saw dust was rich in Cu (45.36 mg/kg) and Zn (502.85 mg/kg). At the final week, the pH of most of the swine based compost was near neutral. The combination of *Giliricidia sepium* and swine dung had the highest N (4.68 %), Zn (804.3 mg/kg) and Cu (75.44 mg/kg). *Leuceana* in combination with swine dung had the highest total P value of 0.26 % while total K was high (1.44 %) in *Panicum maximum* at the final week. However, Ca and Mg decreased at the final week. Conclusively, it can be stated that *Giliricidia sepium, Leuceana* as well as *Panicum maximum* are potential sources of both the macro and micro nutrients when combined with swine dung for compost production.

Keywords: Plant residues, Animal manure, compost production, Macro and micro nutrients.

Introduction

A good source of organic matter is decomposed compost, which is a recycled fertilizer and good as a soil amendment. Increased productivity and sustainable agriculture has been linked to the use of compost in times past, with its ability to solve the declining trend in soil fertility.

Compost although effective in increasing most of the soil physical properties such as improving the aggregate stability, increasing the water holding capacity among other properties has its limitation in supplying all the nutrients needed in the soil for plant growth. Although compost is rich in the micronutrients, it has been observed to supply less of N and moderately supply P and K. Biologically treating wastes whether from animal or plant source is co-composting and this is done towards achieving a sustainable process and zero waste. It has the ability to supply nutrients. Organic matter, total N and C:N ratio contents suitable for soil amendments have been reported with a co-composted cattle manure with rice straw (Qian et al., 2014). Stable organic matter in a matured co-composted pig manure with saw dust was reported in a study by Huang et al. (2006), using chemical and spectroscopic methods. N loss with an initial C/N ratio of 40 was observed with an amended dairy manure of 83% of moisture with either straw dust or

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straw (Michel Jr. et al., 2004). Essential plant nutrients needed by crops such cereals, legumes, vegetables and pastures has been found in swine manure (Choudhary et al., 1996). Also, swine manure has been reported to have an average of 67 % of total N as ammonium-N (Chantigny et al., 2008). Crop residues on the other hand have also been reported to have the potential to enhance soil fertility (Anguria et al., 2017). Also it has also been reported that crop residues have a significant amount of organic matter (Surekha et al., 2003). However, Auguria et al. (2017) also reported that at the initial stage of decomposition of plant residues, N and P are not usually readily available. Combining various crop residues with swine manure will make available most macronutrients for plant uptake. Therefore, this study was carried out to determine the chemical changes that occur during co-composting of swine manure with various plant residues.

Material and Methods

Preparation of the Plant based Compost

The heap method was used. Different plant materials namely cassava peels, Leuceana, saw dust, maize stover, neem clippings, *Panicum maximum, Gliricidia sepium* and banana leaves were composted with swine dung in a ratio 1:1. Composting was done for eight (8) weeks and sampling done at two (2) weeks intervals.

Chemical analysis

The modified Micro-Kjeldahl method was used for total N determination (AOAC, 1980). Total P, K, Ca and Mg was estimated in Aqua Regia digested samples and read on the atomic absorption spectrophotometer (AAS) (Chen and Ma, 2001). The aqua regia method as described by Hseu et al. (2002) was used for the determination of Cu and Zn and also read on the atomic absorption spectrophotometer (AAS). Total P was determined by the method of Jackson (1973). Potassium was measured by flame meter. Compost pH were measured as described by Rhoades (1996) and Blakemore et al. (1981) respectively.

Microbiological analysis

Determination of CO_2 evolution

The incubation-alkaline absorption method (Coleman et al., 1978) was used for the determination of microbial activity. Measurement of the moisture adjusted sub-samples was done according to the method described by Forster (1995). It was then placed in a suspended beaker containing 10 ml of 0.05 M NaOH. Incubation of the jars were done at 25 ^oC for 3 days in the dark immediately after sealing. The CO_2 trapped in NaOH was titrated with 0.05 M HCl at the completion of the incubation period. Respiration rate was calculated using the method of Eze et al. (2013). The amount of CO_2evolved from microbes present per gm of soil per hour (μg CO_2 g^{-1} soil h^{-1}) was used to express the final value.

Determination of bacterial and fungal abundance

At a weekly interval, 1.0 g of compost collected from each compost heap and diluted ten-folds using sterile normal saline. Inoculation of 0.1 ml aliquots from the 10^{-8} dilution onto nutrient agar and potato dextrose agar respectively by the pour plating technique was used to determine the population of viable bacterial and fungal cells in each sample. Incorporation of 50 μg of chloramphenicol/ml (v/v) was used to further make potato Dextrose agar selective for fungi. For bacteria and fungi respectively, incubation was done at 30°C for 24 h and 30°C for 5 days.

Statistical analysis

A 5 x 5 factorial experiment design, replicated three times was used for studies. Data collected were subjected to analysis of variance (ANOVA) using GenStat Discovery Edition 4,10.3D Estatistical software, and where the F-value was significant, treatment means were separated at $P \leq 0.05$ level of significance using Fisher least significant differences (LSD) (Genstat, 2011).

Results and Discussion

Chemical properties of the materials used for the composts

The materials used for the different swine based composts ranged between slightly acidic and moderately alkaline (Table 1). The least pH value was observed for *Giliricidia sepium* (6.50) while the highest value was observed for maize stover. The highest percentage total N was observed for *Giliricidia sepium* (3.63%) while swine dung had the least percentage of N (0.22%). *Giliricidia sepium* also had the highest percentage of P (0.14 %) while banana leaves had the least P value (0.05%). The highest percentage of K was also observed for *Giliricidia sepium* (2.59%) while banana leaves had the least value (0.24 %). Banana leaves was however high in percentage Ca (4.75%), followed by *Giliricidia sepium* (3.76 %) while *Panicum maximum* had the least percentage of Ca (1.57%). The percentage Mg in the materials used was not as high as Ca, however, *Giliricidia sepium* had the highest percentage Mg (1.07%) while banana leaves had the least value (0.30%). Saw dust was rich in both Cu (45.36 mg/kg) and Zn (502.85 mg/kg) while the least values for these two ions i.e Cu and Zn was observed in *Panicum maximum* with 8.97 mg/kg and 177.51 mg/kg values respectively.

Table 1. Chemical properties of the materials used for the composts

Different Composting Materials	pH	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (mg/kg)	Zn (mg/kg)
BL	7.74	2.17	0.05	0.24	4.75	0.30	31.24	203.65
CP	6.92	1.02	0.13	1.30	2.68	0.60	18.54	405.18
GL	6.50	3.63	0.14	2.59	3.76	1.07	20.18	293.42
L	7.59	3.49	0.08	0.48	1.89	1.02	19.11	261.28
MS	8.32	2.22	0.11	0.42	2.17	0.74	16.98	234.58
N	7.54	2.70	0.11	0.45	2.37	0.89	14.85	308.12
PM	7.60	1.72	0.07	1.44	1.57	0.68	8.97	177.51
SW	7.69	1.98	0.13	0.33	2.01	1.01	45.36	502.85
SD	6.80	0.22	0.10	0.35	2.09	0.95	19.07	321.01

Banana leaves- BL, Cassava peel - CP, Gliricida - GL, Leuceana - L, Maize Stover - MS, Neem - N, Panicum maximum - PM, Saw dust - SW, SD- Swine dung

pH of the different swine based composts during the composting period

The pH showed significant differences among the different heaps of the swine based composts during the composting period (Table 2). The pH of the different heaps ranged between slightly acidic and moderately alkaline with combination of *Giliricidia sepium* and swine dung having the lowest pH of 6.5 and the combination of maize residue and swine dung been observed to have the highest pH of 8.32 at the start of the period. Increase in compost pH was observed at the 2nd week for most swine based composts. However, a decrease and later an increase was later observed from the 4th week to the last week of composting. At the completion of the period, pH values was between been near neutral and moderately alkaline. The combination of cassava peels and swine dung had the least pH value of 7.14 while *Panicum maximum* in combination with swine dung had the highest pH value of 8.72 at the 8th week.

Table 2. pH during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	7.74ab	8.81a	8.14a	7.77ab	8.08ab
CP + SD	6.92bc	6.92cd	6.95bc	7.07bc	7.14b
GL + SD	6.50c	6.76d	6.79c	6.85bc	7.35b
L + SD	7.59ab	7.11cd	6.80c	6.43c	7.15b
MS + SD	8.32a	7.81bc	7.75ab	7.53ab	7.72b
N + SD	7.54ab	7.82bc	7.89a	7.35abc	7.76b
PM + SD	7.60ab	8.13ab	8.51a	8.23a	8.72a
SW + SD	7.69ab	7.49bcd	7.73ab	7.64ab	7.56b
FPr	*	*	**	*	*

Letters followed by the same letters are not significantly different from each other *=(p<0.05); **=(p<0.01); ***=(p<0.001); NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Population of fungi in the different swine based composts during the composting period

There were significant differences among the values obtained for the fungal population in the different swine based composts during the composting period (Table 3). The results obtained the combination of *Leuceana* and swine dung had the largest population of fungi (17 x 10^{-7}cfu/ml) while the least population of 4 x 10^{-7}cfu/ml was observed for the combination of neem and swine dung. The fungal population increased at the second week while intermittent decrease and increase was later observed in most heaps till the last week of composting. As compared to the 6th week, the population of fungi decreased at the 8th week.

Table 3. Fungal count (10^{-7}cfu/ml) during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	10 c	16 c	27 b	17 b	10 b
CP + SD	11 b	13 d	8 e	10 e	8 c
GL + SD	2 f	5 h	5 g	3 g	5 e
L + SD	17 a	24 a	69 a	12 d	11 a
MS + SD	1 g	8 f	7 f	7 f	6 d
N + SD	4 e	10 e	12 c	14 c	5 e
PM + SD	11 b	22 b	5 g	7 f	2 f
SW + SD	5 d	7 g	9 d	18 a	11 a
FPr	***	***	***	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Population of bacterial in the different swine based composts during the composting period

As observed for the fungal population in the different heaps, there were significant differences among the bacterial count obtained for the different swine based composts (Table 4). The combination of saw dust and swine dung had the largest population of bacteria (6 x 10^{-7}cfu/ml) while the least population (1.1 x 10^{-7}cfu/ml) was observed in the heap that had the combination of neem and swine dung. The bacterial population increased as observed at the 2nd week, while a decrease and later an increase was observed from the 4th week till the end of period. At the 8th week of the period, the bacterial population then decreased was observed across the different swine based composts.

Table 4. Bacterial count (10^{-7}cfu/ml) during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	1.7bc	6.0d	5.6d	10.4b	3.0d
CP + SD	1.5bc	1.6e	7.2bc	6.8d	7.6a
GL + SD	1.9bc	6.8d	10.8a	19.2a	4.0c
L + SD	1.5bc	2.3e	8.0b	3.1f	4.8c
MS + SD	1.9bc	9.2b	10.8a	2.6f	4.0c
N + SD	1.1c	9.8b	3.0e	5.8e	4.8c
PM + SD	2.1b	12.4a	7.0c	10.2b	4.6c
SW + SD	6.0a	8.0c	7.5bc	7.8c	6.3b
FPr	***	***	***	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

CO_2 evolution of the different swine based composts during the composting period

The results obtained for the CO_2 evolution in the swine based composts showed significant differences among the different heaps (Table 5). The activities of the microorganisms were more in the heap that had a combination of *Leuceana* and swine dung while the least activity was observed for the heap that had a combination of saw dust and swine dung. The activities of the microorganisms increased from the 2nd week to the 4th week and later decreased at the six (6) weeks of composting, which continued till the 8th week.

Table 5. CO_2 evolution (mg CO_2–C kg^{-1}.) during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	2.93b	19.07ab	16.59ab	16.83a	5.39e
CP + SD	2.81bc	15.46c	16.32b	14.46b	7.03b
GL + SD	2.50bc	19.07ab	16.91ab	15.64ab	5.81de
L + SD	4.03a	17.17bc	17.48ab	15.08b	6.46c
MS + SD	1.96cd	15.89c	16.89ab	16.05ab	6.42c
N + SD	2.08bcd	17.96ab	16.80ab	10.94c	4.8 f
PM + SD	2.72bc	18.03ab	18.00a	11.4c	9.84a
SW + SD	1.22d	19.50a	17.84ab	15.64ab	6.16cd
FPr	***	**	*	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Nitrogen content of the different swine based composts during the composting period

Total nitrogen (N) content obtained for the different swine based composts showed significant differences (Table 6). The highest total N content was observed in the combination of *Giliricidia sepium* with swine dung (4.56%) while the least value was obtained in the combination of saw dust with swine dung. Increase in the total N content occurred at the 2nd week, with a decrease at the 4th week for most swine based compost. The total N content later increased at the 6th week and decreased at the 8th week for most of the swine based composts.

Table 6. Nitrogen (%) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	2.830c	2.845c	2.904c	2.904c	2.877c
CP + SD	2.264e	2.382ef	2.443d	2.434d	2.342e
GL + SD	4.558a	4.667a	4.414a	4.603a	4.678a
L + SD	4.189b	4.218b	3.611b	4.109b	4.126b
MS + SD	2.461d	2.525e	2.578d	2.555d	2.571d
N + SD	2.914c	3.086c	2.941c	3.037c	2.990c
PM + SD	2.222e	2.318f	2.264e	2.222e	2.251ef
SW + SD	1.979f	1.998g	1.914f	2.013f	2.125f
FPr	***	***	***	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Phosphorus content of the different swine based composts during the composting period

Significant differences were observed in the phosphorus (P) content of the different swine based composts (Table 7). The percentage P content ranged between 0.12 and 0.3 % at the start of the period and decreased at the 2nd week of the period. The P content increased at the 4th week for most of the swine based compost, decreased at the 6th week and finally increased at the 8th week. The final week of composting, combination of *Leuceana* and swine dung had the highest P content of 0.26% while the least value of 0.14% was observed for the combination of saw dust and swine dung.

Table 7. Phosphorus (%) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	0.30a	0.07b	0.19a	0.14a	0.24a
CP + SD	0.13ab	0.22ab	0.16a	0.20a	0.17a
GL + SD	0.15ab	0.13ab	0.18a	0.19a	0.22a
L + SD	0.17ab	0.15ab	0.21a	0.12a	0.26a
MS + SD	0.12b	0.20ab	0.21a	0.18a	0.21a
N + SD	0.12b	0.26a	0.17a	0.15a	0.19a
PM + SD	0.16ab	0.13ab	0.18a	0.17a	0.17a
SW + SD	0.12b	0.09ab	0.13a	0.14a	0.14a
FPr	*	*	ns	ns	ns

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Potassium content of the different swine based composts during the composting period

At the start of the preparation, there were observed differences in the potassium (K) content of the different swine based composts (Table 8). The combination of banana leaves and swine dung had the highest K content at the start of the preparation while the least value was observed for the combination of saw dust and swine dung. Increase in K content was observed for some of the swine based composts while K decreased in others at the 2nd week. However, generally, the K content increased at the 4th week of composting and later decreased in most heaps at the 6th week. At the completion of the period, increases in K content was observed across the compost heaps. The highest value was observed for the combination of *Panicum maximum* and swine dung (1.44%) which was not significantly different from the value obtained for the combination of *Leuceana* and swine dung (1.41%). The least value in the K content was observed for the combination of saw dust and swine dung.

Magnesium content of the different swine based composts during the composting period

There were observed differences in the magnesium (Mg) content at different stages of the composting period (Table 9). The combination of banana leaves and swine dung had the highest Mg content (1.33%) while the least value (0.62%) was observed for the combination of *Leuceana* and swine dung. Increases in the Mg content occurred at the 2nd week and then decreased at the 4th week. Increase in the Mg content occurred six (6) weeks after the start of the period and then decreased at the 8th week of the composting period.

Table 8. Potassium (%) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	0.74a	0.5bc	0.56de	1.22a	1.35a
CP + SD	0.58b	0.3d	0.26f	0.3c	1.16bc
GL + SD	0.38c	0.73a	1.37a	0.49b	1.34a
L + SD	0.56b	0.46bcd	0.93b	1.37a	1.41a
MS + SD	0.47bc	0.48bc	0.73c	0.42bc	1.32ab
N + SD	0.38c	0.72a	0.52de	0.38bc	1.28abc
PM + SD	0.49bc	0.56b	0.68cd	0.53b	1.44a
SW + SD	0.37c	0.37cd	0.42e	0.28c	1.14c
FPr	***	***	***	***	**

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Table 9. Magnesium (%) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	1.333a	0.829d	1.037a	0.854b	0.6225ab
CP + SD	1.1155b	1.203b	0.81b	1.1145a	0.7855a
GL + SD	0.859cde	1.195b	0.666bc	0.918b	0.5555bcd
L + SD	0.6235f	0.99c	1.09a	0.8985b	0.684ab
MS + SD	0.7095ef	1.278b	1.192a	0.87b	0.52bcd
N + SD	0.93cd	1.037c	0.73bc	0.88b	0.6bc
PM + SD	1.02bc	1.994a	0.591c	0.993ab	0.4285d
SW + SD	0.829de	1.21b	0.687bc	0.972ab	0.442cd
FPr	***	***	***	*	**

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant.

Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Calcium content of the different swine based composts during the composting period

Significant differences were observed across the weeks of composting for the different swine based composts (Table 10). At the start of the period, the highest value for Ca (3.69%) was observed in the combination of maize residue and swine dung while the least value (2.02%) occurred in the combination of *Giliricidia sepium* and swine dung. The Ca content increased as observed at the 2nd week and then started decreasing in most compost heap to the 8th week of composting.

Table 10. Calcium (%) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	2.675c	1.570g	2.515c	1.995e	1.845b
CP + SD	3.315b	2.490f	2.030d	3.110a	1.585c
GL + SD	2.015e	5.635a	1.950d	2.270d	1.855b
L + SD	2.770c	3.720c	3.480b	2.930b	2.335a
MS + SD	3.690a	2.955e	4.620a	2.810bc	1.660c
N + SD	2.460d	4.035b	2.390c	2.190d	1.290d
PM + SD	2.390d	3.025e	1.700e	2.710c	1.395d
SW + SD	2.445d	3.280d	1.885d	1.525f	0.930e
FPr	***	***	***	***	******

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Zinc content of the different swine based composts during the composting period

There were observed differences across weeks of composting as regards the zinc (Zn) content in the different swine based composts (Table 11). At the start of the composting period, the highest value for the Zn content was observed for the combination of cassava peels and swine (485.5 mg/kg) dung while the least value (342.2 mg/kg) was observed for the combination of *Giliricidia sepium* and swine dung. The Zn content decreased as observed in most compost heap at the 2nd week and later increased four (4) weeks after the composting started. At the 6th week, the Zn content increased in some heaps and decreased in others. However, at the 8th week, increase in Zn was observed for some compost heap while a decrease occurred in others. The combination of *Giliricidia sepium* and swine dung had the highest Zn content (804.3 %) while the least value (322.7 mg/kg) was observed for the combination of banana leaves and swine dung.

Table 11. Zinc (mg/kg) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	355.1g	290.5f	434.7c	482.5a	322.7h
CP + SD	485.5a	415.8c	304.1h	481.7b	436.3d
GL + SD	342.2h	405.5d	330.8f	417.4d	804.3a
L + SD	442.6d	288.2g	586.2b	248.7g	323.7g
MS + SD	467.3c	524.3a	305.4g	326.7f	461.2c
N + SD	367.5f	512.3b	367.8e	341.3e	501.4b
PM + SD	431.7e	196.8h	621.2a	445.1c	388.2e
SW + SD	477.6b	383.2e	432.4d	241.2h	326.9f
FPr	***	***	***	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Copper content of the different swine based composts during the composting period

Significant differences were observed in the different swine based composts across the different weeks of composting (Table 12). At the start of the composting period, the combination of maize stover and swine dung had the highest value (46.86 mg/kg) for the copper (Cu) content while the combination of saw dust and swine dung had the least value (23.31 mg/kg). The level of Cu increased as observed at the 2nd week for most swine based composts. However, a decrease and later an increase was observed form the 4th week to the 8th week of the composting period. At the 8th week, the combination of *Giliricidia sepium* and swine dung had the highest level of Cu (75.44 mg/kg) while the value was obtained in the heap that had a combination of saw dust and swine dung.

Table 12. Copper (mg/kg) content during composting of different feed stock

Different Swine based Composts	Initial	2nd Week	4th Week	6th Week	8th Week
BL + SD	36.65b	43.54a	29.06d	68.45a	32.33f
CP + SD	34.46c	40.17d	27.88e	23.44h	35.47e
GL + SD	25.16g	29.55f	19.87h	54.27b	75.44a
L + SD	32.28e	33.46e	38.61b	28.17g	29.44g
MS + SD	46.86a	40.55c	21.67g	34.28e	38.22d
N + SD	32.88d	11.45h	23.14f	47.46c	51.31b
PM + SD	29.84f	28.19g	30.09c	29.16f	48.05c
SW + SD	23.31h	41.02b	41.27a	46.67d	29.18h
FPr	***	***	***	***	***

Letters followed by the same letters are not significantly different from each other *p<0.05; **p<0.01; ***p<0.001; NS= Not Significant. Banana leaves + Swine Dung- BL + SD, Cassava peel + Swine Dung- CP + SD, Gliricida + Swine Dung- GL + SD, Leuceana + Swine Dung- L + SD, Maize Stover + Swine Dung- MS + SD, Neem + Swine Dung- N + SD, Panicum maximum + Swine Dung- PM + SD, Saw dust + Swine Dung- SW + SD

Discussion

The initial chemical analysis carried out on the plant materials used for the different swine based composts showed that *Giliricidia sepium* had higher levels of N, P, K and Mg followed closely by *Leuceana* while the micronutrients studied notably Cu and Zn was high in saw dust. *Giliricidia sepium* has been observed to contain appreciable levels of N, P and K (Gaisie et al., 2016).

The pH of the different swine based composts increased as compared to the initial values obtained for the chemical properties of both the plant and animal source. The liming ability must have been due to the effect of the swine dung present (Adeniyan et al., 2011). However, at the final week of composting the cassava based compost had a near neutral pH, which might be due to the release of acids from the cassava peels and swine dung.

As the decomposition process continued, increase in total N was observed, signifying release of more N into the heaps and this was evident in the heap that had a combination of *Giliricidia sepium* and swine dung. Although total N decreased at the 8th week for most of the swine based composts, increases in N was observed in some heaps and this could probably be due to effect of some of the plant materials which are rich in N (Jeschke and Heggenstaller, 2012). At the 8th week, the combination of *Giliricidia sepium* and swine dung had the highest total N and the contributory material would probably be from *Giliricidia sepium*.

The percentage total P was higher than what was observed for total K in the heaps. However, variability occurred across the weeks of composting as regards the percentage total P in the heaps but at the final week, the combination of *Leuceana* and swine dung had the highest percentage P. *Leuceana* among other green manures have been reported to be rich in P.

The initial high level of K in the combination of banana leaves and swine dung would have been due to richness of banana leaves in K (Mayadevi, 2016). However, variability occurred across the weeks of composting as regards K but the final composts was rich in K. Combining either *Panicum maximum* or *Leuceana* with swine dung had relatively higher total K value than other swine based composts. *Leuceana* and *Panicum maximum* have been identified as potential source of organic matter among other nutrients (Asaolu et al., 2014).

The secondary nutrients notably Ca and Mg, although present at the initial starting material was not highly available at the completion of the period. However, the combination of *Leuceana* and swine dung showed a potential of making Mg available over time while this observation was observed in the combination of *Giliricidia sepium* and swine dung for Ca.

For the micronutrients at the start of the period, the high level of Zn observed in the combination of cassava peels and swine dung. This could have been due to the reports of presence of Zn in cassava peels (Otache et al., 2017) coupled with the contributory factor from swine dung, which has also been reported to be rich in the micronutrients (Eteng, 2015). However, at the final week, the combination of *Giliricidia sepium* and swine dung had the highest Zn content and this could have been due to initial high levels of Zn in *Giliricidia sepium* and swine dung, which would have jointly contributed to the final high value.

For Cu, the initial high level observed in the combination of maize stover and swine dung could have been due to a quick release of Cu into the heaps. Variability occurred across the composting period but at the 8th week, the high level of Cu in the combination of *Giliricidia sepium* and swine dung could be attributed to the initial high Cu content of *Giliricidia sepium* which was then released over time coupled with the contributory richness of swine dung in Cu (Eteng, 2015).

As regards the microbial population, there were more of fungi in the compost heaps than bacteria, probably because of the lignin content in the plant materials (Varma et al., 2017). This was evident in neem with a low population of both fungi and bacteria while a high microbial population was evident in the plant materials used. However, at 8 weeks, a decrease in the microbial population occurred, signifying compost maturity and invariably stability.

The CO_2 evolution signifying activities of the microorganisms was low at the start of the period probably due to limited supply of factors such as aeration and temperature (Varma, 2015) among other factors that lead to increase in the activities of the microbes. The activities of the microorganisms started increasing at the 2nd week probably due to increase in the compost temperature from the 2nd to the 6th week (Ribeiro et al., 2017). However, at the 8th week, there was less activity of the microorganisms signifying a reduction in the decomposition process and invariably stability.

Conclusion

It was evident that there were more of fungi than bacteria in the compost heaps probably due to the lignin content in the different plant materials and their activities was more between the 2nd and 6th week signifying the period when rapid decomposition took place. However, the nutritive value of the plant materials especially *Giliricidia sepium*, *Leuceana* and *Panicum maximum* was established in terms of the high N, P, K, Cu and Zn at the end of the eight week.

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