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Physiochemical Parameters of Composited Cow and Goat Waste as Mitigation to Municipal Waste

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Abstract: *Introduction*: Municipal Solid Waste (MSW) is an emerging global issue which is mainly affecting municipalities in many countries. According to the Word Bank, an estimated 2.24 billion tonnes of solid waste was generated in 2020, it is expected that by 2050, 3.88 billion tonnes of waste will be generated annually, which is 73% increase from the 2020 level of waste generation. Indiscriminate dumping of refuse creates serious environmental problems to humans and the ecosystem. Composting is one of low cost biological which is catalysed by microbial activities. The physical-chemical parameter affected by this process include temperature, aeration, moisture content, Carbon:Nitrogen ratio and pH. *Materials and Methods*: It was an applied study. Mixed market waste was collected from the traders in the market and taken straight to the receiving bay (shed). The biodegradable organic materials were sorted from the non-biodegradable materials for the compost. The organic solid wastes used for compositing were divided into 4 treatment groups of Cow Manure with organic waste (CM), Goat Manure with organic waste (GM), Cow and Goat Manure with organic waste (CGM) and Organic Waste alone (OW). *Results*: The treatment group of organic wastes alone (OW) had the highest mean weight of 224±2.00 at baseline and 61.50±1.50 post treatment. GM had a mean of 201.0±1.00 at baseline and 67.00±3.00 post treatment. Chemical analysis showed that the matured compost consisted of the following: Carbon, Nitrogen, phosphorus, and Potassium. CM and GM gave a C:N ratio was 15:1 each, an indication of high nitrogen, resulting to fast decomposition of the biomass. Chemical analysis of CGM showed a C:N ratio of 16:1 while compost made without the addition of the ruminant wastes OW gave a C:N ratio of 18:1 which is an indication of low nitrogen resulting to the slow decomposition of the biomass. During the composting process, pH, temperature and moisture content of the composts ranged between 6.5-8.3, 30°C-61°C, and 30-63% respectively. *Conclusion*: Conversion of solid organic waste into manure helps to minimize environmental pollution. Basic essential nutrients in chemical fertilizers such as nitrogen, phosphorus and Potassium present in compost will however reduce the need for synthetic fertilizers.

Keywords: Composting, Waste, Cow Manure, Goat Manure

1. Introduction

Municipal Solid Waste (MSW) is an emerging global issue which is mainly affecting municipalities in many countries. It has become a challenging task for municipalities across the world to manage solid organic waste in the cities and implement an effective and sustainable system for the citizens [1]. According to the Word Bank, the rate of waste generation keep rising, an estimated 2.24 billion tonnes of solid waste was generated in 2020, this indicates that 0.78 kilograms of waste is been generated per person per day. Due to industrial development, immense economic growth, rapid urbanization and population growth, it is expected that by 2050, 3.88 billion tonnes of waste will be generated annually, which is 73% increase from the 2020 level of waste generation [2].

The management of solid organic waste and market sanitation constitutes one of the most immediate and environmental challenges facing the Nigerian community today. Wastes also threaten the integrity of habitats that are essential to biological diversity. Indiscriminate dumping of refuse creates serious environmental problems to humans and the ecosystem. This also results to increase in infant and under-five morbidity and mortality rate [3]. The MSW composition in a country influences the technology selection for waste management treatment. The high organic content in the MSW has resulted in higher moisture content in the MSW composition that lowers the calorific value. This condition causes thermal treatment to be a less favourable choice, making biological treatment such as composting and anaerobic digestion (AD) more preferable [4].

Among the various treatments in managing the organic waste such as the use of landfill and incineration, decaying organic wastes by using biological processes is considered as more suitable solution method. Composting is one of low cost biological decomposition process. The composting process is catalysed by microbial activities. The physical-chemical parameter affected by this process include temperature, aeration, moisture content, Carbon:Nitrogen ratio and pH [5].

Wastes generated in Bodija market are found on the surroundings of the market areas, resulting to children's sources of contamination due to the proliferation of flies, mosquitoes, and rodents; that, transmits disease causing gastrointestinal, dermatological, respiratory, genetic, and several other types of infectious diseases. Wastes also threaten the integrity of habitats that are essential to biological diversity.

Consequently, market wastes have a very high economic and social cost in the public health services, and have not yet been estimated by governments, industries, and families. Reuse of organic waste is considered desirable, in general, for resource management and also as a way for urban authorities to substantially reduce the amount of waste requiring disposal and treatment [6].

Ibadan, the capital city of Oyo State is located in the southwestern part of Nigeria, with the largest commercial city in the tropical Africa with over 56 organized markets to provide for the city's increasing population, yet has no effective and scientific means of wastes disposal, resulting to a lot of environmental problems such as flood, pollution, congestion and other related health problems [7]. Indiscriminate dumping of refuse and poor environmental sanitation creates serious environmental problems to humans and the ecosystem. This also results to increase in infant and under-five morbidity and mortality rate [3].

The problems associated with disposal of wastes are many and they include littering of food and other solid organic wastes in the market area. One of the negative consequences of management of solid waste from the market is its unsafe and inappropriate disposal which results in health risks and unpleasant conditions in the market. This can lead to the breeding of rats and other vectors of diseases of public health importance [8]. Rats are destructive and their activities can lead to eating of the food items of the market men and women and for infected rats, it will cause the consumers of such food items health disorder such as lassa fever, dysentery etc.

2. Materials and Methods

2.1. Processing of the Compost

2.1.1. Waste Collection

The mixed market waste was collected from the traders in the market and was taken straight to the receiving bay (shed). The waste comprises of banana, plantain, potato, pepper, vegetable leaves, amala, tomato, avocado pear, onion, nylon, papers, 'moimoi' wrappers and cherry (agbalumo).Necessary chopping and shredding was done as per requirement as it helps speed up decomposition and hasten the process of composting by increasing the surface area available for microbial action, and providing better aeration [9-11].

2.1.2. Sorting the Mixed Market Waste

Sorting of the mixed market waste was done in one of the windrows. The biodegradable organic materials were sorted from the non-biodegradable materials for the compost. This was done using the compost fork and the shovel. Sorting of these waste was done for a week to ensure that the appropriate quantity needed for the compost is sorted before mixing and loading of the compost into the windrows.

2.1.3. Weighing of the Wastes

The weight of the waste generated from the market which was used for this study was measured using the weighing scale balance. The quantity used for each compost was also weighed.

2.1.4. Loading of Waste Materials into Windrows

The sorted mixed market waste was transferred from the point of sorting to the windrow/chambers manually using the head pan. The sorted wastes were weighed and loaded into four chambers respectively. In the process of laying the mixed market waste for composting, the intestinal wastes of the ruminants (cow and goat) was also laid until the quantity needed is reached. This was done for the four compost heaps (pile).

2.1.5. Homogeneous Mixing and Turning of the Compost

Turning of the mixture started from the edge where the mixed market waste and the animal waste were laid using the compost fork and shovel and finally was made into heaps to a height of about 100-150m. During the period of the composting, the mixture was turned for proper aeration and to avoid putrefaction. Thorough turning of the mixture was achieved.

2.1.6. Wetting of Compost Windrows

The moisture content of the compost was monitored regularly using the compost moisture content meter. About 25 litres of water was added to each heap on daily basis depending on the state of the compost.

2.1.7. Curing of the Compost

The matured compost was cured for 20 days to get rid of any pathogenic microorganism present in it. This was done to ensure safety of handlers and increase soil fertility. It was done by leaving it for additional 20 days without turning or watering.

2.1.8. Production Line

This process involves milling, sieving, packaging and storage of the produced compost. After the curing process, the compost was milled using the compost milling machine and was manually sieved with a 2cm mesh to get a fine particle of the compost prior to bagging and storage.

2.2. Method of Data Collection

The following parameters were measured using the compost thermometers;

1. Daily Temperature readings/changes from the composts in the various heap and control.
2. Moisture content of the composts from the windrows and controls.
3. Daily monitoring of the pH readings of the composts and controls.
4. Characterization of the ruminant wastes and the compost.
5. Carbon, Nitrogen, Phosphorous, Potassium (C, N, P, K) and C:N ratio were determined using standard analytical methods as described by the American Public Health [12].

2.3. Physicochemical Variations in the Composting Process

2.3.1. Temperature

The temperature of the pile was taken by inserting a compost thermometer 25cm deep into the pile for 3minutes and the temperature immediately read while the thermometer was still in the waste. The readings were taken daily at different positions of the compost heaps and the mean temperature recorded.

2.3.2. pH Determination

Changes in hydrogen ion concentration were measured daily using a compost pH meter. This was done by inserting a long pH meter 25cm deep into the compost pile for 3mins and the pH read while the meter was in the wastes.

2.3.3. Moisture Content

Daily monitoring of the moisture content was done using the moisture content meter. The readings of the moisture content was done just like in the temperature and pH readings.

2.4. Chemical Characterization of the Solid Wastes

2.4.1. Nitrogen Determination

Determination of nitrogen expressed in percentage was done using Kjeldahl distillation and titrimetric method as described by the Association of Official Analytical Chemist [13].

(i). Pre-Treatment of Nitrogen Sample

Reagents: Selenium catalyst tablet, concentrated Sulphuric acid (H_2SO_4), 0.01N/HCl, 40%NaOH, 4% Boric Acid, methyl red indicator.

(ii). Digestion of the Sample

Oven dried ground waste of 0.5g and compost samples was weighed carefully into the kjeldahl digestion tubes and ensured that all sample materials got to the bottom of the tubes. To this sample, 1 selenium catalyst tablet and 10ml of conc. H_2SO_4 was added and taken to the digestion block heaters in the fume cupboard and heated to a temperature of 550°C. The sample was left to digest for 4hours until a colorless solution was got. The digest was allowed to cool and was carefully transferred into a 100ml volumetric flask, thoroughly rinsing the digestion tube with distilled water and made up to mark.

(iii). Determination of Nitrogen

The distillation was done using Markham distillation Apparatus which allows volatile substances such as Ammonia to be steam distilled with complete collection of the distillate. The apparatus was steamed out for about 10mins. 5ml of the digest was pipette into the body of the apparatus through the small funnel aperture. To this was added 5ml of 40% (w/v) NaOH through the same opening with the 5ml pipette.

The mixture was steamed for 2mins into a 50ml conical flask containing 10ml of 4% Boric Acid with mixed indicator solution placed at the receiving tip of the condenser. The Boric Acid plus indicator solution changed from red to green showing that all the ammonia liberated has been trapped. The green solution obtained was then titrated against 0.01N HCl placed in a burette. At the end point, the green colour turns to a wine colour which indicates that all the Nitrogen trapped as Ammonium Borate [$(NH_4)_2BO_3$] have been removed as Ammonium chloride (NH_4CL).

$$\%N \text{ of sample} = \frac{TV \times NHCl \times 14 \times 100}{W \times VS} \times 100$$

Where,
TV = Titre value;
NHCl = Normality of HCl (0.01N);
W= Weight of the sample;
VS= Volume of digest for steam distillation;
14= Atomic mass of Nitrogen;
100= Volume of flask containing the digest.

2.4.2. Phosphorous Determination (Vanado-Molybdate Spectrophotometric Method)

Determination of total phosphorus as P_2O_5 in the raw organic waste was done spectrophotometrically, using the Mo (molybdovanadate) blue colour method of Murphy and Riley [14].

Reagents: Ammonium molybdate; antimony potassium tartrate; 2.5MH_2SO_4 (148ml conc. H_2SO_4 diluted to 1 litre); potassium hydrogen phosphate (KH_2PO_4); ascorbic acid; P-Nitrophenol (0.25% wt/vol); 5MNaOH and 5MHCl.

(i). Procedure

From ammonium molybdate, 12g was taken and dissolved in 250ml of distilled water. Also, 0.2908g of antimony potassium tartrate was dissolved in 100ml of distilled water.

The two dissolved reagents were added to 1000ml of 2.5M H_2SO_4 and mixed thoroughly before being made up to 2 litres.

Then, the mixture was labeled as A and stored in pyrex glass vessel in dark cool temperature.

At the time of analysis, 1.056g of ascorbic acid was dissolved in 200ml of the reagent A above. It was then mixed thoroughly and labeled as B.

From the digested sample, 5ml was pipette into 50ml volumetric flask and then made up to 40ml with distilled water. To this solution was added 8ml of reagent B and the mixture was thoroughly mixed.

The absorbance of the coloured solution was matched against a reagent blank at 882nm, after staying for 30 minutes.

(ii). Preparation of Standard Curve

From dry KH_2PO_4, 0.2194Kg, was taken, dissolved in distilled water in 500ml flask and then made up to mark. This standard P stock solution contained 100ugP/ml.

From the stock solution above, 5ml was taken and diluted to 100ml in 100ml volumetric flask. This solution contained 5ug P/ml.

Then from the diluted solution above, 2ml, 4ml, 6ml, 8ml, and 10ml was pipette separately into 50ml flask each and the volume was made up to 35ml with distilled water.

To each of these diluted samples, 8ml of reagent B was added and mixed thoroughly before the volume was made-up to the mark (50ml) with distilled water. These solution contained 0.2, 0.4, 0.6, 0.8, and 1.0 ug P/ml respectively.

Total Phosphorus in the sample was calculated as follows:

$$\text{Total P} = \frac{12.7 * 50 * AB * 10}{\text{Weight of sample} * 10{,}000}$$

Where AB is the absorbance at 882nm.

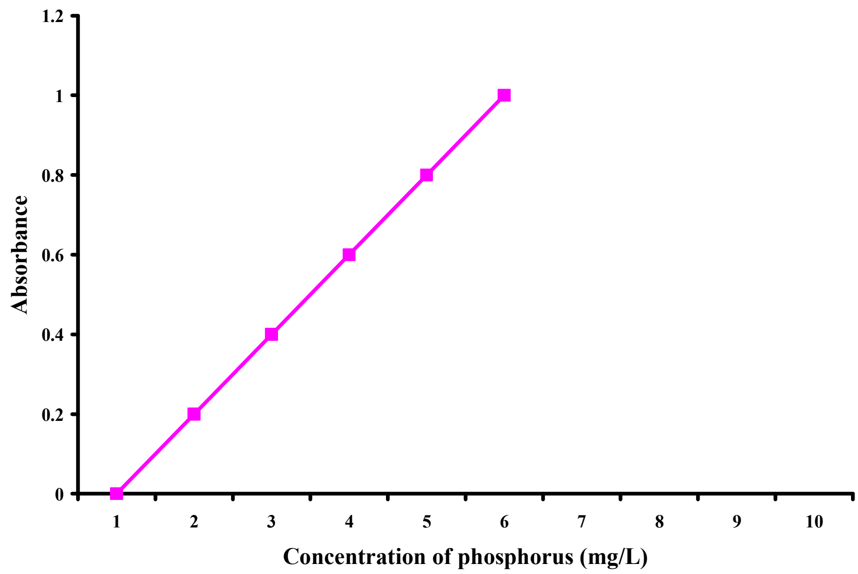

Figure 1. *Calibration Curve for Phosphorus (Expressed as P_2O_5).*

2.4.3. Determination of Potassium

0.5g of the sample was weighed in a crucible and put in a furnace and heated at 55°C for 4hours. The ash of the sample obtained was treated by adding 5ml of 2MHCL solution in a crucible and heated to dryness on a heating mantle. 5ml of 2 MHCL was added to the residue and allowed to boil and was filtered through whatman No. 1 filter paper placed in a glass funnel into a 100ml volumetric flask. The filtrate was made up to mark using distilled water, stoppered and ready to read the concentration of potassium on the Jenway Digital Flame Photometer (PFP7 Model). The amount of potassium present in the solution from the calibration curve was read by plotting absorbance readings against potassium concentrations. The calibration curve was prepared by using the aliquots of the standard solution.

$$\% \text{ of K in sample} = \frac{\text{Concentration} \times 0.125}{\text{Weight of the sample}}$$

Where, 0.125 is the dilution factor.

2.4.4. Determination of Carbon

0.5g of a well ground organic wastes and compost was weighed, 10ml of 1N $K_2Cr_2O_7$ and swirled gently which was followed by rapid addition of 20ml of conc. H_2SO_4 (0.255N) in a conical flask. Distilled water was added to make up to 150ml of the mark on the conical flask. To the conical flask, 10 drops of diphenylamine indicator was added making the colour dark violet. Due to the addition of H_2SO_4, it is allowed to cool and finally titrated against 0.5N ferrous Ammonium Sulphate which changed the dark violet colour to green at the end point. This was repeated for the blank and the concentration of carbon in sample was calculated as follows.

$$\% \text{ C in sample} = \frac{N\,(T-B) \times 0.004}{\text{Weight of sample}}$$

Where,
W = Weight (in grams) of the sample;
T = Total volume of $FeSO_4 \cdot 7H_2O$ used in titrating sample;
B = Volume of $FeSO_4 \cdot 7H_2O$ used in titrating blank;

N = Normality of$FeSO_4 \cdot 7H_2O$ (0.4N).

Note: 1ml of $K_2Cr_2O_7$ = 0.003g Carbon. However the reaction is approximately 75% complete, therefore, 1ml of $K_2Cr_2O_7 = \frac{0.003g \times 100}{75}$.

To calculate the organic matter =% Organic carbon × 1.724.

2.4.5. Determination of Heavy Metals in Samples

The determination of zinc, copper, cadmium and lead in the organic, intestinal waste as well as the compost produced were all done by weighing 1g of the ground compost in a conical flask. Conc. HNO_3 and Conc. H_2SO_4 were the digestion reagent used and 5ml each was added to the conical flask containing the sample and heated until brown peroxide and white perchloric acid evaporated. The resulting residue was totally dried. The procedure was repeated until there was a white precipitate appeared in the flask, it was then filtered through No. 1 Whatman filter paper into a 100ml volumetric flask. The filtrate was diluted using 0.1N HNO_3 and made up to 100ml. The digested samples were then analyzed for heavy metals and micronutrients using Bulk Scientific 210/211 VCP Atomic Absorption Spectrophotometer (AAS) according to the method described by the American Public Health Association [12].

3. Result

3.1. Physical Characterization of Wastes

Organic solid wastes generated in Bodija market that was used for this study were biodegradable in nature and were mostly abundant in the market. They include vegetable leaves, onions, potatoes, pepper, tomatoes, yam, grass clippings, food remnant. Also, some non-biodegradable wastes such as rags, nylons, tins, glass, plastics, and metals were found.

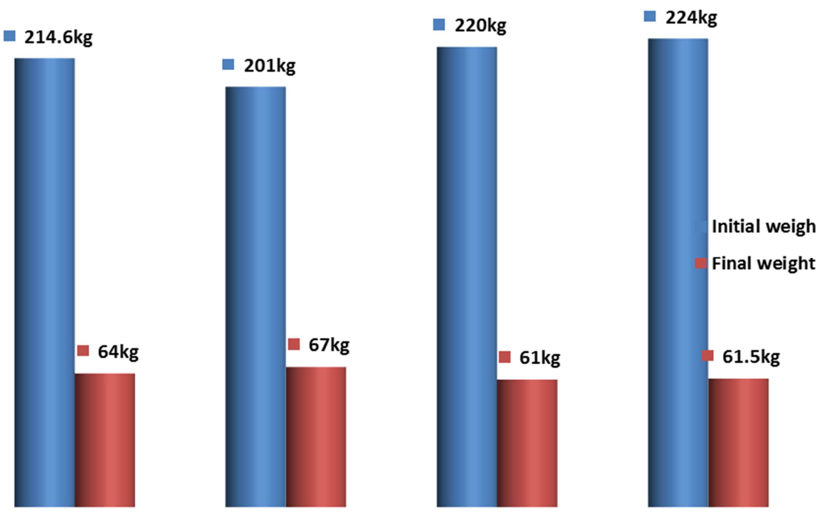

Figure 2. *Initial weight of wastes used for composting and end product (compost).*

Key:
CM-Cow Manure with organic wastes (3:1)
GM-Goat Manure with organic wastes (3:1)
CGM-Cow, goat Manure with organic wastes (3:1:1)
OW-Organic Wastes alone.

3.2. Composting as a Wastes Management and Reduction Strategy

The volume of organic solid wastes used for composting in the four treatment groups was significantly reduced after the composting process. Reduction in the quantity of wastes generated is the major importance of composting. The treatment group organic wastes alone (OW) had the highest mean weight of 224±2.00 at baseline and 61.50±1.50 post treatment. GM had a mean of 201.0±1.00 at baseline and 67.00±3.00 post treatment. Other groups and there level of reduction is as shown in Figure 2. OW, CGM, CM and GM had 73%, 72%, 70%, and 60% reduction after composting.

Table 1. *Organic Carbon, Nitrogen content, Phosphorus, Potassium and C:N Ratio in the Organic Manure (%).*

Parameters	Goat Manure	CowManure	Raw Wastes
Organic Carbon	31.06±0.02	35.53±0.06	40.11±0.01
Nitrogen	3.56±0.06	3.77±0.04	2.48±0.03
Potassium	6.06±0.06	8.68±0.06	6.39±0.04
Phosphorus	13.88±0.03	10.09±0.06	11.79±0.07
C:N ratio	9:1	9:1	16:1
Calcium ($mgkg^{-1}$)	1.71±0.11	2.07±0.09	1.48±0.06

Parameters	Goat Manure	CowManure	Raw Wastes
Sodium (mgkg^{-1})	1.11±0.05	0.82±0.04	1.07±0.08
Magnesium (mgkg^{-1})	1.90±0.11	1.85±0.04	1.04±0.06
Zinc (mgkg^{-1})	100.19±0.05	100.48±0.08	100.79±0.09
Copper (mgkg^{-1})	4.29±0.02	3.24±0.05	5.36±0.04
Lead (mgkg^{-1})	3.68±0.06	3.49±0.04	3.49±0.04
Cadmium (mgkg^{-1})	3.04±0.05	2.14±0.04	2.90±0.07

Table 2.*Chemical Characteristics of Cured Compost Produced From OrganicWaste.*

Parameters	CM	GM	CGM	OW
C (%)	20.86 ± 0.06	19.43 ± 0.04	21.06 ± 0.05	15.21 ± 0.07
N (%)	1.42 ± 0.04	1.33 ± 0.04	1.31 ± 0.03	0.86 ± 0.05
C/N	15:1	15:1	16:1	18:1
P (%)	7.44 ± 0.05	8.25 ± 0.07	7.87 ± 0.06	8.11 ±0.05
K (%)	6.08 ±0.04	7.78± 0.05	5.21±0.03	5.23± 0.06
Na (mgkg^{-1})	0.86± 0.08	0.78± 0.09	0.73± 0.06	0.56± 0.03
Ca (mgkg^{-1})	1.20± 0.04	1.28± 0.03	1.77± 0.07	1.60± 0.04
Mg (mgkg^{-1})	2.14± 0.04	1.84± 0.05	1.69± 0.06	2.08± 0.01
Cu (mgkg^{-1})	4.43±0.01	4.55± 0.07	3.67± 0.04	3.81± 0.04
Pb (mgkg^{-1})	3.27± 0.03	3.25± 0.05	2.19± 0.02	2.13± 0.05
Cd (mgkg^{-1})	2.21± 0.08	2.07± 0.04	2.15± 0.04	1.47± 0.05
Zn (mgkg^{-1})	100.02± 0.03	98.06± 0.05	97.03± 0.04	100.05± 0.00

Key: CM= Cow Manure with organic wastes; GM=Goat Manure with organic wastes; CGM= Cow Goat Manure with organic wastes; OW= Organic Wastes alone.

3.3. Chemical Characteristics of Raw Organic Wastes

Table 1 shows the results of chemical analysis performed on the organic wastes sample with C:N ratio of about 16:1, 9:1 and 9:1 for raw organic solid wastes, goat and cow manure respectively. Solid organic market wastes showed a carbon content of 40.11±0.01% in the chemical analysis before the co-composting while the ruminant wastes showed carbon content of 31.06±0.02% and 35.53±0.06% respectively for goat and cow manure. The nitrogen content of cow was shown to be 3.77±0.04% and greater than that of the goat (3.56±0.06%) but not statistically different. The raw wastes showed nitrogen content of 2.48±0.03%. These raw wastes were also analyzed for Potassium and phosphorus; 6.06±0.06 and 13.88±0.03% for goat manure respectively, potassium (8.68±0.06) and phosphorous (10.09±0.06) for cow manure respectively and for the raw solid wastes are 6.39±0.04 and 11.79 ± 0.07 respectively.

Table 1 also show that the calcium content (mgkg^{-1}) present in the rumen of the cow was higher than the goat. Sodium and magnesium content of the goat were higher as compared to cow and the raw solid wastes respectively. The heavy metals in (mgkg^{-1}) analyzed include zinc, copper, lead and cadmium for the raw wastes.

3.4. Chemical Characteristics of Cured Compost Produced from Organic Fertilizer

Chemical analysis showed that the matured compost consisted of the following: Carbon, Nitrogen, phosphorus, and Potassium. CM gave a C:N ratio was 15:1, an indication of high nitrogen, resulting to fast decomposition of the biomass. Organic fertilizer GM gave a C:N ratio of 15:1. Chemical analysis of CGM showed Carbon, Nitrogen, phosphorus and Potassium with a C:N ratio of 16:1. Compost made without the addition of the ruminant wastes OW gave a C:N ratio of 18:1 which is an indication of low nitrogen resulting to the slow decomposition of the biomass. The compost CGM, had the highest carbon and phosphorous content, while organic wastes alone (OW) had the lowest carbon content as shown in Table 2.

Table 3.*Comparative Analysis of Physico-Chemical Properties of the MaturedCompost CM and GM.*

S/N	Parameters	CM	GM	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	20.86 ± 0.06	19.43 ± 0.04	0.000*
2	% Nitrogen	1.42 ± 0.04	1.33 ± 0.04	0.112
3	%Phosphorous	7.44 ± 0.05	8.25 ± 0.07	0.000*
4	%Potassium	6.08 ±0.04	7.78 ± 0.05	0.000*
5	Sodium (mgkg^{-1})	0.86 ± 0.08	0.78 ± 0.09	0.299
6	Calcium (mgkg^{-1})	1.20 ± 0.04	1.28 ± 0.03	0.272
7	Magnesium (mgkg^{-1})	2.14 ± 0.04	1.84 ± 0.05	0.005*
8	Copper (mgkg^{-1})	4.43 ±0.01	4.55 ± 0.07	0.195
9	Lead (mgkg^{-1})	3.27 ± 0.03	3.25 ± 0.05	0.591
10	Cadmium (mgkg^{-1})	2.21 ± 0.08	2.07 ± 0.04	0.048*
11	Zinc (mgkg^{-1})	100.02 ± 0.03	98.06 ± 0.05	0.000*

Key: CM= Cow Manure with organic wastes; GM=Goat Manure with organic wastes; * = Shows that it is significant.

3.4.1. Comparative Analysis of Physico-Chemical Properties of the Matured Compost CM and GM

Comparative analysis between CM and GM using the multiple comparison/post-hoc test showed a significant difference at P< 0.05 as shown in Table 3. Difference in means between phosphorus and potassium were also significant for CM and GM respectively at P<0.05. The Magnesium content present in CM was more and also significant to GM at P<0.05. There was a significant difference in cadmium and zinc between CM and GM. Nitrogen, sodium, calcium, copper and lead parameters showed no significant difference.

Table 4.*Comparative Analysis of Physico-Chemical Properties of the MaturedCompost CM and CGM.*

S/N	Parameters	CM	CGM	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	20.86 ± 0.06	21.06 ± 0.05	0.392
2	% Nitrogen	1.42 ± 0.04	1.31 ± 0.03	0.060
3	%Phosphorous	7.44 ± 0.05	7.87 ± 0.06	0.000*
4	%Potassium	6.08 ±0.04	5.21 ±0.03	0.000*
5	Sodium ($mgkg^{-1}$)	0.86 ± 0.08	0.73 ± 0.06	0.083
6	Calcium ($mgkg^{-1}$)	1.20 ± 0.04	1.77 ± 0.07	0.000*
7	Magnesium ($mgkg^{-1}$)	2.14 ± 0.04	1.69 ± 0.06	0.001*
8	Copper ($mgkg^{-1}$)	4.43 ±0.01	3.67 ± 0.04	0.000*
9	Lead ($mgkg^{-1}$)	3.27 ± 0.03	2.19 ± 0.02	0.000*
10	Cadmium ($mgkg^{-1}$)	2.21 ± 0.08	2.15 ± 0.04	0.378
11	Zinc ($mgkg^{-1}$)	100.02 ± 0.03	97.03 ± 0.04	0.000*

Key: CM= Cow Manure with organic wastes; CGM= Cow Goat Manure with organic wastes; * = Shows that it is significant.

3.4.2. Comparative Analysis of Physico-Chemical Properties of the Matured Compost CM and CGM

Table 4 show that the mean organic Carbon and Phosphorous of CGM were high and significantly different P<0.05 as compared to CM while Potassium for CM is higher and showed a significant difference to CGM P<0.05.Nitrogen content of CM showed a high mean but was not significantly different from CGM P>0.05. The mean Sodium $mgkg^{-1}$ content of CM is high than in CGM and showed no significance P = 0.08, P>0.05. Comparing Calcium and Magnesium between CM and CGM respectively was significant at P<0.05. The mean heavy metals of lead, copper and zinc were higher in CM and significantly different to CGM (P<0.05) except Cadmium which showed no statistical significant different but the mean was found to be higher in CM) than in CGM at P = 0.378.

3.4.3. Comparative Analysis of Physico-Chemical Properties of the Matured Compost CM and OW

Chemical analysis result compared between CM and OW was shown to be significant with P<0.05. Percentage organic carbon, Nitrogen and Potassium of CM are higher in means and was significantly different to OW with P <0.05. Sodium and Calcium for CM and OW were significantly different at P = 0.003, 0.001 respectively with P< 0.05, while Magnesium showed no significance (P = 0.447) on comparison with CM and OW, though the mean of CM was high to OW. Lead, Copper and Cadmium contents were high in CM and showed significant difference with OW (P<0.05) while Zinc was not significant (P = 0.673) but higher in OW than in CM Table 5.

Table 5.*Comparative Analysis of Physico-Chemical Properties of the Matured Compost CM and OW.*

S/N	Parameters	CM	OW	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	20.86 ± 0.06	15.21 ± 0.07	0.000*
2	% Nitrogen	1.42 ± 0.04	0.86 ± 0.05	0.000*
3	%Phosphorous	7.44 ± 0.05	8.11 ±0.05	0.000*
4	%Potassium	6.08 ±0.04	5.23 ± 0.06	0.000*
5	Sodium ($mgkg^{-1}$)	0.86 ± 0.08	0.56 ± 0.03	0.003*
6	Calcium ($mgkg^{-1}$)	1.20 ± 0.04	1.60 ± 0.04	0.001*
7	Magnesium ($mgkg^{-1}$)	2.14 ± 0.04	2.08 ± 0.01	0.447
8	Copper ($mgkg^{-1}$)	4.43 ±0.01	3.81 ± 0.04	0.000*
9	Lead ($mgkg^{-1}$)	3.27 ± 0.03	2.13 ± 0.05	0.000*
10	Cadmium ($mgkg^{-1}$)	2.21 ± 0.08	1.47 ± 0.05	0.000*
11	Zinc ($mgkg^{-1}$)	100.02 ± 0.03	100.05 ± 0.00	0.673

Key: CM= Cow Manure with organic wastes; OW= Organic Wastes alone * = Shows that it is significant.

Table 6.*Comparative Analysis of Physico-Chemical Properties of the MaturedCompost CGM and OW.*

S/N	Parameters	CGM	OW	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	21.06 ± 0.06	15.21 ± 0.07	0.000*
2	% Nitrogen	1.32 ± 0.04	0.86 ± 0.05	0.000*
3	%Phosphorous	7.87 ± 0.06	8.11 ±0.05	0.006
4	%Potassium	5.22 ±0.04	5.23 ± 0.06	0.710
5	Sodium (mgkg^{-1})	0.73 ± 0.06	0.56 ± 0.03	0.048*
6	Calcium (mgkg^{-1})	1.77 ± 0.07	1.60 ± 0.04	0.054
7	Magnesium (mgkg^{-1})	1.69 ± 0.06	2.08 ± 0.01	0.001*
8	Copper (mgkg^{-1})	3.67 ±0.04	3.81 ± 0.04	0.137
9	Lead (mgkg^{-1})	2.19 ± 0.02	2.13 ± 0.05	0.187
10	Cadmium (mgkg^{-1})	2.15 ± 0.04	1.47 ± 0.05	0.000*
11	Zinc (mgkg^{-1})	97.03 ± 0.04	100.05 ± 0.00	0.000*

Key: CGM= Cow Goat Manure with organic wastes; OW= Organic Wastes alone; * = Shows that it is significant.

3.4.4. Comparative Analysis of Physico-Chemical Properties of the Matured Compost CGM and OW

Percentage Carbon and Nitrogen were significant with P<0.05 when compared. Phosphorous and Potassium were not significantly different but was higher in OW than in CGM (P = 0.006 and 0.710) respectively with P>0.05. Comparison of the chemical parameters in (mgkg^{-1}) Sodium, Calcium, Cadmium and Zinc between CGM and OW showed a significant difference at P = 0.048, 0.054, 0.000 and 0.000 with P< 0.05 whereas Calcium, Copper and Lead showed no significant difference where, P = 0.054, 0.137, 0.187 respectively with P> 0.05 as shown in Table 6.

Table 7.*Comparative Analysis of Physico-Chemical Properties of the Matured Compost CGM and GM.*

S/N	Parameters	CGM	GM	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	21.06 ± 0.06	19.43 ± 0.04	0.000*
2	% Nitrogen	1.32 ± 0.04	1.33 ± 0.04	0.682
3	%Phosphorous	7.87 ± 0.06	8.25 ±0.07	0.000*
4	%Potassium	5.22 ±0.04	7.78 ± 0.05	0.000*
5	Sodium (mgkg^{-1})	0.73 ± 0.06	0.78 ± 0.09	0.399
6	Calcium (mgkg^{-1})	1.77 ± 0.07	1.28 ± 0.03	0.000*
7	Magnesium (mgkg^{-1})	1.69 ± 0.06	1.84 ± 0.05	0.092
8	Copper (mgkg^{-1})	3.67 ±0.04	4.55 ± 0.07	0.000*
9	Lead (mgkg^{-1})	2.19 ± 0.02	3.25 ± 0.05	0.000*
10	Cadmium (mgkg^{-1})	2.15 ± 0.04	2.07 ± 0.04	0.189
11	Zinc (mgkg^{-1})	97.03 ± 0.04	98.0 ± 0.00	0.000*

Key: CGM= Cow Goat Manure with organic wastes; GM=Goat Manure with organic wastes; * = Shows that it is significant.

Table 8.*Comparative Analysis of Physico-Chemical Properties of the Matured Compost OW and GM.*

S/N	Parameters	OW	GM	P-value
		Mean±SD	Mean±SD	
1	%Organic carbon	15.21 ± 0.07	19.43 ± 0.04	0.000*
2	% Nitrogen	0.86 ± 0.05	1.33 ± 0.04	0.000*
3	%Phosphorous	8.11 ± 0.05	8.25 ±0.07	0.048*
4	%Potassium	5.23 ±0.06	7.78 ± 0.05	0.000*
5	Sodium (mgkg^{-1})	0.56 ± 0.03	0.78 ± 0.09	0.013*
6	Calcium (mgkg^{-1})	1.60 ± 0.04	1.28 ± 0.03	0.003*
7	Magnesium (mgkg^{-1})	2.08 ± 0.01	1.84 ± 0.05	0.013*
8	Copper (mgkg^{-1})	3.81 ±0.04	4.55 ± 0.07	0.000*
9	Lead (mgkg^{-1})	2.13 ± 0.05	3.25 ± 0.05	0.000*
10	Cadmium (mgkg^{-1})	1.47 ± 0.05	2.07 ± 0.04	0.000*
11	Zinc (mgkg^{-1})	100.05 ± 0.00	98.0 ± 0.00	0.000*

Key: OW= Organic Wastes alone; GM=Goat Manure with organic wastes; * = Shows that it is significant.

3.4.5. Comparative Analysis of Physico-Chemical Properties of the Matured Compost CGM and GM

Organic carbon was significantly different with P<0.05 when CGM was compared with GM. The matured compost CGM also gave a higher mean than GM as shown in Table 7. A significant difference was also seen in Phosphorous and Potassium with P < 0.05 although the mean content of Phosphorous, Potassium and Sodium is higher in GM than in CGM. Calcium was significantly different with P<0.05 and higher in CGM than in GM. The heavy metals Copper, lead and zinc were significantly different with P< 0.05 and higher in GM than CGM as shown in Table 7.

3.4.6. Comparative Analysis of Physico-Chemical Properties of the Matured Compost GM and OW

All the parameters showed a significant difference when GM was compared to OW with $P < 0.05$ although there were differences in their means. Carbon, Nitrogen, Phosphorous, Potassium, Sodium, Copper, Lead and Cadmium had higher means than OW while Calcium and Zinc were higher in OW as shown in Table 8.

Table 9.*Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	40.00±5.00	CM vs OW	0.374
		GM	35.00±4.00	GM vs OW	0.548
3	Temperature (°C)	CGM	38.00±2.00	CGM vs OW	0.762
		OW	37.00±3.83	CM vs CGM	0.548
				GM vs CGM	0.374
		CM	63.00±0.00	CM vs OW	0.305
		GM	60.00±1.00	GM vs OW	0.060
	Moisture Content	CGM	61.00±0.00	CGM vs OW	0.305
		OW	62.00±2.00	CM vs CGM	0.060
				GM vs CM	0.011*
		CM	6.50±0.10	CM vs OW	1.000
		GM	6.50±1.73	GM vs OW	1.000
	pH	CGM	6.60±0.17	CGM vs OW	0.899
		OW	6.50±0.70	CM vs CGM	0.899
				GM vs CGM	0.899
		CM	50.00±0.00	CM vs OW	0.001*
		GM	48.00±1.00	GM vs OW	0.005*
6	Temperature	CGM	55.00±5.00	CGM vs OW	0.000*
		OW	40.00±0.00	CM vs CGM	0.043*
				GM vs CGM	0.010*

Table 10.*Comparative Effect of the Compost Parameters (Temperature, Moisture Content and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	58.00±3.00	CM vs OW	0.044*
		GM	55.00±0.00	GM vs OW	0.245
	Moisture Content	CGM	54.00±4.00	CGM vs OW	0.405
		OW	51.67±4.16	CM vs CGM	0.171
				GM vs CGM	0.716
		CM	6.70±0.30	CM vs OW	0.531
		GM	6.80±0.10	GM vs OW	1.000
	pH	CGM	6.80±0.20	CGM vs OW	1.000
		OW	6.80±0.00	CM vs CGM	0.531
				GM vs CGM	1.000
		CM	55.00±5.00	CM vs OW	0.097
		GM	60.00±10.00	GM vs OW	0.023*
9	Temperature	CGM	56.00±3.00	CGM vs OW	0.073
		OW	45.00±6.00	CM vs CGM	0.856
				GM vs CGM	0.474
		CM	50.00±0.00	CM vs OW	0.040*
		GM	50.00±0.00	GM vs OW	0.040*
	Moisture Content	CGM	52.00±0.00	CGM vs OW	0.000*
		OW	49.00±1.00	CM vs CGM	0.001*
				GM vs CGM	0.001*
	pH	CM	8.40±0.10	CM vs OW	0.774
		GM	8.20±0.30	GM vs OW	0.399

Table 11.*Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CGM	8.30±0.70	CGM vs OW	0.569
9	pH	OW	8.50±0.30	CM vs CGM	0.774
				GM vs CGM	0.774
		CM	57.00±3.00	CM vs OW	0.001*
		GM	58.00±1.00	GM vs OW	0.000*
12	Temperature	CGM	58.00±2.00	CGM vs OW	0.000*
		OW	47.00±3.00	CM vs CGM	0.623
				GM vs CGM	1.000

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	50.00±10.00	CM vs OW	0.272
		GM	47.00±2.00	GM vs OW	0.650
	Moisture Content	CGM	50.00±2.00	CGM vs OW	0.272
		OW	45.00±0.00	CM vs CGM	1.000
				GM vs CGM	0.500
		CM	8.00±0.00	CM vs OW	1.000
		GM	8.00±1.00	GM vs OW	1.000
	pH	CGM	8.00±0.87	CGM vs OW	1.000
		OW	8.00±1.00	CM vs CGM	1.000
				GM vs CGM	1.000

Table 12. *Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	60.00±5.00	CM vs OW	0.574
		GM	60.00±5.00	GM vs OW	0.574
15	Temperature	CGM	61.00±4.00	CGM vs OW	0.405
		OW	58.00±2.00	CM vs CGM	0.777
				GM vs CGM	0.777
		CM	45.00±1.00	CM vs OW	1.000
		GM	44.00±0.00	GM vs OW	0.764
	Moisture Content	CGM	46.00±6.00	CGM vs OW	0.764
		OW	45.00±3.44	CM vs CGM	0.764
				GM vs CGM	0.551
		CM	7.80±0.20	CM vs OW	0.580
		GM	7.70±0.20	GM vs OW	0.282
	pH	CGM	7.80±0.10	CGM vs OW	0.580
		OW	7.90±0.30	CM vs CGM	1.000
				GM vs CGM	0.580
		CM	60.00±5.00	CM vs OW	0.150
		GM	58.00±2.00	GM vs OW	0.368
18	Temperature	CGM	58.667±2.31	CGM vs OW	0.277
		OW	55.00±5.00	CM vs CGM	0.683
				GM vs CGM	0.837

Table 13.*Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	40.00±2.00	CM vs OW	0.269
		GM	42.00±0.00	GM vs OW	0.569
	Moisture Content	CGM	41.00±3.00	CGM vs OW	1.000
		OW	41.00±2.00	CM vs CGM	0.569
				GM vs CGM	0.569
		CM	7.60±0.20	CM vs OW	0.545
		GM	7.50±0.10	GM vs OW	1.000
	pH	CGM	7.60±0.30	CGM vs OW	0.545
		OW	7.50±0.10	CM vs CGM	1.000
				GM vs CGM	0.545
		CM	58.00±1.00	CM vs OW	0.001*
		GM	52.00±3.00	GM vs OW	0.227
21	Temperature	CGM	58.00±2.00	CGM vs OW	0.001*
		OW	50.00±0.00	CM vs CGM	1.000
				GM vs CGM	0.004*
		CM	36.00±0.00	CM vs OW	0.685
		GM	37.00±3.00	GM vs OW	0.425
	Moisture Content	CGM	38.00±0.00	CGM vs OW	0.243
		OW	35.00±5.00	CM vs CGM	0.425
				GM vs CGM	0.685
		CM	7.40±0.00	CM vs OW	1.000
		GM	7.40±0.10	GM vs OW	1.000
	pH	CGM	7.30±0.10	CGM vs OW	0.122
		OW	7.40±0.00	CM vs CGM	0.122
				GM vs CGM	0.122

Table 14. *Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	42.00±3.00	CM vs OW	0.402
		GM	45.00±2.00	GM vs OW	0.670
24	Temperature	CGM	47.67±1.26	CGM vs OW	0.143
		OW	44.00±4.00	CM vs CGM	0.036*
				GM vs CGM	0.271
		CM	35.00±1.00	CM vs OW	0.060
		GM	34.00±0.00	GM vs OW	0.305
	Moisture Content	CGM	35.00±2.00	CGM vs OW	0.060
		OW	33.00±0.00	CM vs CGM	1.000
				GM vs CGM	0.305
		CM	43.00±5.00	CM vs OW	0.656
		GM	40.00±8.66	GM vs OW	0.823
27	Temperature	CGM	42.00±3.46	CGM vs OW	0.823
		OW	41.00±0.00	CM vs CGM	0.823
				GM vs CGM	0.656

Key: CM= Cow Manure with organic wastes; GM=Goat Manure with organic wastes; CGM= Cow Goat Manure with organic wastes; OW= Organic Wastes alone; * = Shows that it is significant.

Table 15. *Comparative Effect of the Compost Parameters (Temperature, MoistureContent and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	32.00±0.00	CM vs OW	ND
		GM	33.00±0.00	GM vs OW	ND
	Moisture Content	CGM	33.00±0.00	CGM vs OW	ND
		OW	33.00±0.00	CM vs CGM	ND
				GM vs CGM	ND
		CM	7.10±0.00	CM vs OW	1.000
		GM	7.00±0.00	GM vs OW	0.040*
	pH	CGM	7.20±0.00	CGM vs OW	0.040*
		OW	7.10±0.10	CM vs CGM	0.040*
				GM vs CGM	0.001*
		CM	38.00±3.00	CM vs OW	0.238
		GM	37.00±0.87	GM vs OW	0.541
30	Temperature	CGM	39.00±2.00	CGM vs OW	0.092
		OW	36.00±1.00	CM vs CGM	0.541
				GM vs CGM	0.238
		CM	32.00±0.00	CM vs OW	0.282
		GM	33.00±3.00	GM vs OW	0.122
	Moisture Content	CGM	33.00±3.00	CGM vs OW	0.122
		OW	30.00±0.00	CM vs CGM	0.580
				GM vs CGM	1.000

Key: CM= Cow Manure with organic wastes; GM=Goat Manure with organic wastes; CGM= Cow Goat Manure with organic wastes; OW= Organic Wastes alone; * = Shows that it is significant.

Table 16. *Comparative Effect of the Compost Parameters (Temperature, Moisture Content and pH) by Days.*

Days	Parameters	Treatment Groups	Mean ± SD	Multiple Comparism	P-value
		CM	7.00±0.00	CM vs OW	1.000
		GM	7.00±0.00	GM vs OW	1.000
	pH	CGM	7.10±0.10	CGM vs OW	0.040*
		OW	7.00±0.00	CM vs CGM	0.040*
				GM vs CGM	0.040*

Key: CM= Cow Manure with organic wastes; GM=Goat Manure with organic wastes; CGM= Cow Goat Manure with organic wastes; OW= Organic Wastes alone; * = Shows that it is significant.

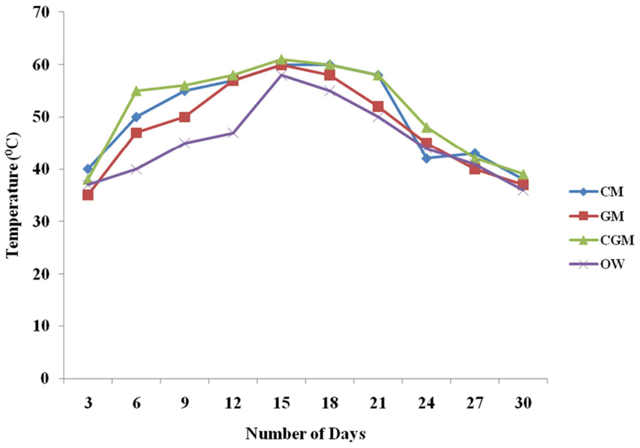

Figure 3. *Temperature Conditions Observed During Composting of OrganicWastes.*

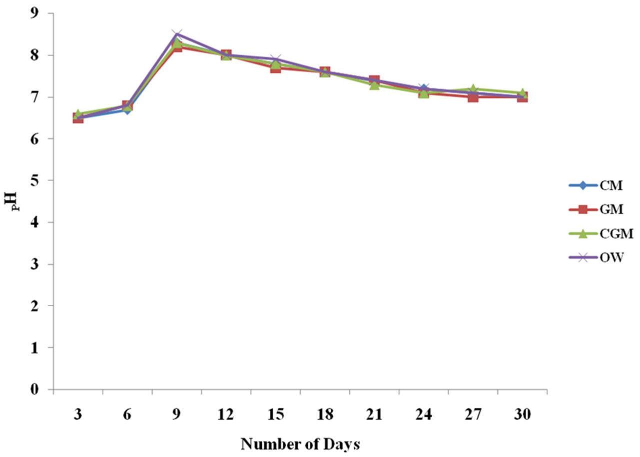

Figure 4. *pH Conditions Observed During Composting of Organic Wastes.*

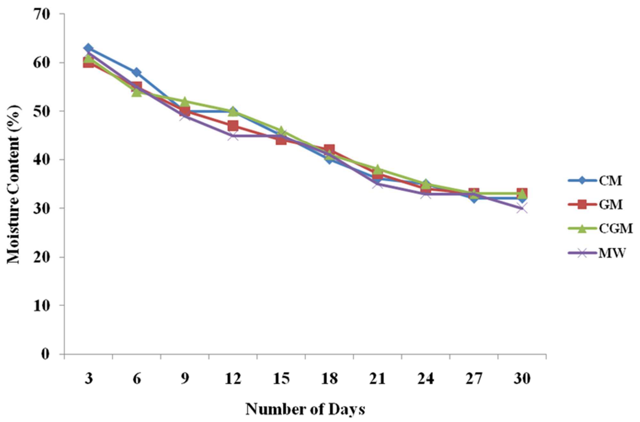

Figure 5. *Moisture Content Conditions Observed During Composting of Organic Wastes.*

3.5. Comparative Effect of the Compost Parameters (Temperature, Moisture Content and pH)

During the composting process, pH, temperature and moisture content of the composts ranged between 6.5-8.3, 30°C-61°C, and 30-63% respectively. At the start of the experiment, the temperature was low and increased to 40°C, 35°C, 38°C and 37°C for CM, GM, CGM and OW respectively on the 3rd day of the compost. Also, there was no significant difference in temperature, moisture content and pH of the compost when different treatment groups were compared using post hoc test except with CM and GM which showed a significant difference at P=0.011, (P<0.05). CM had the highest mean temperature and moisture content while GM showed the lowest with P>0.05. The pH in the 3rd day for all the treatment groups was all 6.5 except in CGM which was 6.60.

Temperature and moisture content in the 6th day showed significant differences (P<0.05) among the groups but there but there was no significant difference in pH. The significant difference of CM vs. OW, GM vs. OW, CGM vs. OW, CM vs. CGM and GM vs. CGM are P = 0.001, 0.005, 0.000, 0.043 and 0.010 respectively with (P<0.05).The moisture content present in CM was significant to OW at P =0.044. For the other treatment groups, there were difference in their means but was not statistically different as shown in Table 9.

The organic fertilizer GM in the 9th day of the composting, had the highest mean temperature and was significant to OW at P<0.05, which had the lowest mean. The treatment groups when compared amongst them with reference to moisture content showed a significant difference at P<0.05. CM compared to OW was significant at P= 0.040, GM vs. OW (P= 0.040), CGM vs. OW (P = 0.000), CM vs. CGM (P = 0.001) as shown in Table 9. There were also differences in the means of the pH but were not statistically different though OW had the highest mean and GM the lowest. It was observed that the compost became alkaline on the 9th day.

Temperature of CM in the 12th day of monitoring was compared with OW and it showed a significant difference at P = 0.001, GM and CGM were significant as compared to OW at P = 0.000 (P < 0.05). The highest temperature attained in the 12th day was 58°C and that was observed in GM and CGM while the lowest mean temperature was OW (47.00±3.00°C). The moisture content in the 12th day ranged between 45-50% and showed no significant difference when compared among the groups as seen in Table 11. The pH for all the groups was 8.00. (P>0.05).

There was no significant difference in temperature, moisture content and pH in the 15th day. It was observed that the difference in the values among the groups were slightly different from each other as all the treatment groups were greatly increased in temperature. CGM (61.00±4.00 and 46.00±6.00) gave the highest mean temperature and moisture content respectively while OW (7.90±0.30) had the highest pH mean.

The 18th day showed no significant difference in temperature, moisture content and pH as the parameters remained or slightly changed like in the 15th day. Temperature in CM (58.00±1.00°C) and CGM (58.00±2.00°C) was significantly different from OW (50.00±0.00°C) with P<0.05 in the 21st day of composting. Moisture content and pH showed no significant difference on comparing within the treatment groups.

On the 24th day, the temperature declined drastically to 42.00±3.00°C, 45.00±2.00°C, 47.67±1.26°C and 44.00±4.00°C for CM, GM, CGM and OW respectively. When CGM was compared with CM, it showed a significant difference with P<0.05 (P=0.036). Comparison among treatment groups for moisture content and pH showed no significance (P>0.05). The compost continued declining in temperature, moisture and pH. The 27th day showed no significant difference in temperature and moisture content. pH was significantly different when GM and CM was compared to OW at (P=0.040). CGM was also significantly different when compared to OW with P<0.05. Table 15.

Temperature and moisture content were not significant on the 30th day but showed significant differences in pH as compared among the groups with (P<0.05) Table 16.

4. Discussion

4.1. Physical Characterization of Wastes

According to Olaseha, I, Sridhar, M. and Oyewo, O [15] the type of vegetables and other food items sold included: vegetables (25.9%), pepper (23.6%), beans (15.4%), rice (10.4%), millet (8.1%), melon (5%), Garri (local Cassava meal) (8.6%) and locust beans (Iru). Non-biodegradable materials such as polythenes are also produced. In this study, some grams of polythenes were weighed and used for composting to know if there are microorganisms present in the ruminants' wastes that can digest the nylon; it was observed that throughout the composting process, the nylons were not degraded.

4.2. Chemical Analysis of the Manure

According to Karak, *et al* [16] in his study of compositing of plant residues using cow dung stated that organic waste enriched with cow manure have a nitrogen content of 3.5% and the value obtained in this study (3.77%) is comparable to that obtained from Karak, *et al* [16], though higher. In a study by Velthof, G.L, Nelemana, J.A, Oenema, O and Kuikman, P.J [17] using pig manure, it was observed that the organic carbon values ranged from 14.3 to 47.2% and total nitrogen values from 4.4% to 7.0%. Reference [18], showed lower total nitrogen value, 2.6% using poultry and sheep manure on fruits, vegetables and plant residues. According to [19] also, the value of total nitrogen in his study (3.5%) fall within the range reported in this study. All the values obtained in these studies show a close range in values obtained for animals (cow and goat) manure investigated in this study.

According to Kolade, O, Coker, A, Shridah, M, and Adeoye, G [20] goat manure has a content of 26.4 to 38.1% organic carbon and 1.4 to 2.3% total nitrogen. Reference [19] show values of 1.99% total nitrogen. The nitrogen content (3.56%) of goat manure in this study is close to the findings of Moral. R, Moreno-Caselles, J, Perez-Murcia, M.D, Perez-Espinosa, A, Rufete, B and Paredes, C. [21] having nitrogen per cent of 3.62. The organic carbon of goat manure in this study agrees with the results of Kolade, O, Coker, A, Shridah, M, and Adeoye, G [20]. The value of potassium and phosphorus obtained in this study is higher than that in the study of Al-Nawaiseh, A.R, Aljbour S.H, Al-Hamaiedeh, H, El-Hasan, T, Hemidat, S and Nassour, A. [18].

4.3. Chemical Characteristics of Solid Wastes

Determination of chemical characteristics of solid wastes is important in evaluating the processing and recovery options. The primary nutrient required by microorganisms for growth are carbon (C), nitrogen (N), phosphorous (P) and potassium (K), where C and N play vital role in the composting process Jusoh, M.L.C, Manaf, L. A. and Latiff P [23]. These include the moisture contents around 60-70% and Carbon to Nitrogen (C/N) ratios of 30/1.

The C/N ratio of some selected organic materials has been shown to be in the range of 1:1 -15:1. However, compost samples showed a higher value of C/N ratio such as 11:1 - 23:1 those with lower C/N ratio are readily decomposed by microbes, which eliminate the need to supplement with N sources to enhance degradation according to Jusoh, M.L.C, Manaf, L. A. and Latiff P [23]. However, materials, which have a C/N ratio of 20, may need supplementation of N to enhance the decomposition rate. Chemical analysis of raw organic wastes used in this study shows a C:N ratio of 16:1, an indication of low nitrogen content, resulting to a slow decomposition of the biomass hence a nitrogen source supplement (animal manure) is necessary for the composting process. This is because, at lower ratio, there will be high value of nitrogen and ammonia will be given off and this slows down the rate of biological activities in the compost [24]. At baseline, the chemical constituent of organic wastes showed significant reduction of nitrogen (2.5%), potassium (6.4%) and phosphorous (11.8%) content after the composting process. The value of nitrogen content present in the raw organic wastes in this study agrees with the findings of Okin A.O [25] on composting school wastes and animal manure in Ibadan. Furthermore, in the study of Okin A.O [25] potassium and phosphorus were significantly reduced after the composting, which agrees with the values of potassium and phosphorus found in this study. Concentrations of NPK in the compost (1.31%, 5.21% and 7.87%) were high compared to the Ontario compost guideline limits (0.6%, 0.3% and 0.2%). The nitrogen content of the organic compost was significantly lower in CM (1.42%), GM (1.34%), CGM (1.32%) and OW (0.86%) when compared with the fresh sample of the raw wastes (2.48%). This result is in contrast with the findings Jusoh, M.L.C, Manaf, L. A. and Latiff P [23], which showed an increase in the N-content from 1.7% to 3.5%. This increase is due mainly to the carbon loss during composting. The organic carbon contents gradually decreased from 40.11% of raw wastes to 20.86%, 19.44%, 21.06% and 15.22% of CM, GM, CGM and OW compost respectively after composting. A continuous decline in water-soluble organic carbon has been reported earlier by Inbar, Y, Hadar, Y. and Chen, Y.

[26] for cattle manure and municipal solid wastes respectively. A decline in organic carbon is one of the indicators of compost maturity [22].

Sodium and potassium were decreased during composting in CM, CGM and OW (6.08, 5.21mg/kg^{-1} and 5.23mg/kg^{-1}, respectively). Reference [27] in his study of composting and vermicomposting of green leafy spinach showed a decrease in Potassium and Sodium during composting from 16.9 and 779 to 7.0 and 143mg/g, respectively. In the study of Elvira, C, Sampedro L, Benitez E. and Nogales R. [28] have reported similar observations during composting of industrial tannery sludge. Reference [27] during vermicomposting of green leafy spinach reported the content of potassium (9.546 mg/g) and sodium (7.683 mg/g) to be lower as compared to fresh sample. This may be due to leaching of these soluble elements by water. Some other authors have also observed similar trend for potassium and sodium in different types of organic wastes [29, 30]. Phosphate content in composted sample (7.44, 8.25, 7.87 and 8.11 mg/kg^{-1}) for CM, GM, CGM and OW was found to be lower than the fresh organic sample (11.79 mg/kg^{-1}).

The result of the chemical analysis of the composts produced showed that the chemical constituent of the compost were within the guideline limit. The C:N ratio of the finished composts CM, GM, CGM and OW were 15:1, 15:1, 16:1, 18:1 respectively, conforming with the guideline limits of 17:1 for C:N ratio of finished compost according to the [31] which stated the C:N ratio of municipal wastes will have a range of 14-16:1. According to [32] the compost is deemed mature if C:N ratio is $\leq$ 25 and these compost products are less than 25.

4.4. Heavy Metals in Compost

Poletschny, H. et al. [33] revealed a lot of concern has been shown regarding reduction in the levels of heavy metals concentrations present in compost and that bio-waste composts contained on average 1/4 the metals content of MSW composts. The extensive studies by Kraus and Grammel [34] concerning the transport and fate of heavy metals, polychlorinated Biphenyls (PCBs) and dioxins in the waste stream and composts raised concern regarding indiscriminate mixing of wastes. This led to a gradual shutdown of MSW composting plants, starting first in Germany and through Switzerland, Austria and eventually France [35].

Data obtained in the laboratory analysis of the selected heavy metals in the organic wastes and the finished compost CGM were lower than the standards in some developed countries such as Canada, Germany and USA [36]. The values of heavy metals obtained from this study were also less than the values obtained by Ogunbanwo [37] in his study on influence of compost from sea weeds on heavy metal dynamics in the soil-plant system. Various studies have shown reduction in heavy metals levels during composting. Reduction in heavy metal levels during composting agrees with the work of Huerta-Pujol, O, Gallart, M, Soliva, M, Martinez-Farre, F.X, Lopez, M [38] who emphasized that the levels of heavy metals can be reduced as a result of composting. Reference [39] shows separation of the organic fraction of waste at the source has help to promote the minimization of contamination level of the resulting products.

4.5. Temperature Variations Observed During Composting

Temperature is one of the key indicators of composting. It determines the rate at which many of the biological processes take place and plays a selective role on evolution and succession on the microbiological communities [40]. From this study, it was observed that the compost temperatures ranged between 35°C and 61°C. The temperature range obtained in this study agrees with the findings of Kadir, A.A, Azhari, N.W. and Jamaludin. S. N [5], which emphasized that a maximum temperature of 55-65°C is necessary to destroy pathogens. At the initial stage of decomposition, the temperature of the organic wastes was 40°C which corresponded with the findings of Khanh, P.T. and Ngoc, T.T.H. [22] which emphasized that the mesophilic organisms (bacteria) that survive temperature ranges from 50°F (10°C) to 113° (45°C) break down soluble and easily degraded compounds during the initial decomposition of organic wastes. Temperature controls protocol of composting states that the internal windrows temperature should remain above 60°C but below 70°C [41].

4.6. Moisture Contents of the Compost Heaps and the Influence of Turnings on the Compost

The presence of water in compost serves to support activities of the microflora during the process. Therefore, compost should have moisture content as high as possible so as to promote the activities of bacteria. Airflow control i.e. proper aeration and water addition are key steps in the composting process control [42]. The moisture content of the compost heaps gave mean percentage values of 56%, 56%, 55% and 58% for CM, GM, CGM and OW respectively on the 5th day which is the first turning day, and on the 10th day of the composting which is the second turning gave mean values of 48%, 49%, 51%, and 47% respectively for the various compost heaps.

The result showed that as the composting period progresses, the percentage moisture content decreases from a mean value of 63%, 60%, 61% and 62% to 32%, 33%, 33%, 30% for CM, GM, CGM and OW respectively for the third day and thirty day. This clearly shows that water is being utilized by the microorganisms therefore, moisture content decreases after each turning of the compost heaps. For a successful composting according to Ramaswamy, J, Prasher, S.O, Patel, R.M, Hussain, S.A. and Barrington, S.F [43] the moisture contents during the curing process must be above 40%, so that both bacteria and fungi re-colonizes the compost after peak heating. This moisture strategy not only speeds up the process but also decreases dust problems and reduces the load of fungal spores down wind from the site which is further reduced by beneficial colonizing compost after peak heating only if adequate moisture is present [42]. Moisture content, therefore also should be managed carefully during the curing. However, laboratory analysis to determine the moisture contents of the curing compost piles were not done due to logistic problems rather the compost moisture content meter was used to monitor the moisture contents and this showed good results.

4.7. pH Readings of the Compost Heaps

The pH of the compost pile started with 6.5 for all the groups. Effect of pH on first turning gave mean values of 6.7, 6.7, 6.8, and 6.8. On the 10^{th} day, mean values of 8.1, 8.2, 8.3, 8.3 and 7.1, 7.0, 7.2, 7.2 respectively for CM, GM, CGM and OW on the 25^{th} day. This showed various degree of Alkalinity and values are not consistent but generally it could be said to be increasing in Alkalinity. The variation of pH in this study is similar to Benito, M, A. Masaguer, A. Moliner, N. Arrigo and Palma, R.M [44], who propounded that pH of his compost increased during the early stage (first ten days) of decomposition with a low pH of (6.76) then it continued to increase slowly, and after the 15^{th} day of composting pH value were highest about 8.68 and after that, remained constant at 6.75 in all the four consecutive years of His study. In this study, the pH peaked to 8.5 on day 9 considering with highest release of ammonia by the composting manure. Reference [43], in a typical compost pile the pH will start at about 6.5 and decline due to acid production then reach to a stable value for mature compost.

Decrease in the earliest stage of composting, could be likened to the production of organic acids derived from the intense fermentation of carbohydrates. Afterwards, the pH begins to rise which results from the release of ammonia due to the start of proteolytic process [22]. pH drop during thermophilic metabolism is due to accumulation of organic acids which reflects high rate of organic matter degradation and these acids are used later on as substrate by other microorganisms. During the cooling down and maturation stages the pH drops to a neutral value [43].

The pH value of compost is looked as an indicator of process of decomposition and stabilization. The change of pH value during composting is quite predictable [44, 22].

5. Conclusion

Conversion of solid organic waste into manure helps to minimize environmental pollution in cities around the world. Compost offers basic essential nutrients in chemical fertilizers such as nitrogen, phosphorus and Potassium. This however will minimize the need for synthetic fertilizers. Although composting is a safe form of organic waste treatment, many cities do not have any organized waste management services leading to the disposal of waste haphazardly.

A knowledgeable incorporation of compost will play a critical role in improving soil and plant growth in disturbed urban soils. Further research needs to be carried out to identify an acceptable range of compost characteristics that should be used for soil remediation in urban landscape. The qualities of composts should also be tested using a standard testing protocol such as TMECC protocol.

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