# AEROBIC COMPOSTING OF CASSAVA PEELS USING COWDUNG, SEWAGE SLUDGE AND POULTRY MANURE AS SUPPLEMENTS.

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## ABSTRACT

*Cassava peels, poultry manure, cowdung, sewage sludge and grass clippings are common wastes with resourceful fertilizer value but often indiscriminately discarded, thereby constituting environmental pollution. This paper studied the use of poultry manure, cowdung and sewage sludge as supplements for composting of cassava peels. In this study, these wastes were used to prepare different composts. Compost pile A was prepared by mixing cassava peels with sewage sludge and grass clipping in a ratio of 1:1:1 by weight. The second pile B was prepared by combining cassava peels, poultry manure and grass clippings also in 1:1:1 ratio by weight. The third pile C had a blending of cassava peels, cowdung and grass clippings in a ratio of 1:1.5:1 by weight. The fourth pile a control D was prepared by mixing cassava peels with grass clippings in ratio of 1:1 by weight. In all the piles, Total Organic Carbon (TOC) losses had significant effect on N, P,K, Na, Ca, and Mg content. There existed significant negative correlations between TOC losses and other nutrients. The composted products containing the various supplements had higher contents of micro nutrients such as N, P, K than pile D (control) without supplement. The Ca, Na and Mg contents were higher in composts with supplements with the exception of pile C. The E. coli values for all piles fall within the USEPA limits of less than $3 \times 10^4$ (cfu/g). Pile B slightly got to maturity state before piles A and C, while pile D (control) took much longer period. Cassava peels, sewage sludge, cowdung and poultry manure are potential materials for a good compost but poultry manure induced the early maturity of the composting than other supplements and contributed to the nutritional content of the compost.*

**Keywords:** Aerobic composting, cowdung, sewage sludge, poultry manure.

## INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the world's most important food crops. Nigeria is the largest world producer of the crop with the growing and processing left in the hands of subsistence farmers. In the processing of cassava fermented products, the most common by-products are cassava peels, foliage, starch bagasse, wastewaters, discarded roots and barks. The rate of generation of these wastes is on the increase due to demand for cassava products such as cassava fufu and flour for bread making due to a recent government policy. The peels and barks make up about 10-13% and 6-7% of total cassava weight respectively (Andrea *et al.*,2010). With hand peeling which is common among subsistence farmers, the peels can constitute 20-25% of the total weight of the tuber (Ekundayo 1980). The cassava peels are usually indiscriminately discarded and allowed to rot thus contaminating soil and water bodies and generating foul odour. Presently, the most common method of handling cassava peels is composting which is also a means of recycling. The other alternative is direct usage as animal feed. Cassava peels normally have high concentration of cyanogenic glucosides, which makes the peels unsuitable for animal feed (Obulua 2007). The peels constitute an important potential resource if properly harnessed biotechnologically (Obadina *et. al.,* 2006) with composting as a promising method of handling.

Cowdung, poultry litter, and sewage sludge are wastes products with high fertilizer value and of economic importance if properly harnessed, managed and not indiscriminately disposed. Heavy metals and organic compounds are present in sewage sludge. These pose an indirect risk to human health, pollute groundwater and accumulate in plants when applied directly on land (Oleszczuk 2006). Cow manure in particular contains high levels of ammonia and potentially dangerous pathogens with composting recommended prior to its use as fertilizer (Phipps 2011). In addition to the micronutrients, poultry manure contains Ca, Mg, S, which are important to the soil when stabilized through composting (Hailin 2005).

Composting is one of the most suitable approaches for disposal of pultrescible solid waste and for increasing the amount of organic matter content that can be used to restore and preserve the environment (Stentiford, 1987). Previous composting studies on cassava peels include Kamolmanit and Reungsang, (2007) and Olaniyi and Akanbi, (2008). These emphasized the optimization of operations to achieve a high decomposition rate and a stabilized end product**.** However, in most of these studies, only one supplement was examined, while comparisons among various supplements were seldom addressed. This study analyzes the rate of decomposition of cassava peels with different supplements and assesses the quality of the compost in terms of nutrient and feacal coliforms reduction.

## STUDY SITE DESCRIPTION.

The study was conducted in Ibadan located in the South Western part of Oyo State of Nigeria. Onipepeye cassava processing centre is one of the major cassava fermentation stations in Ibadan. Research experiments were conducted in the Soil and Water shed of the Agricultural and Environmental Engineering Department, University of Ibadan, Ibadan Nigeria.

## MATERIALS AND METHODS

In this study, three designed experiments and one quality control run were set up for the composting study. Four pilot scale compost bins each with dimension 0.6x0.6x0.6m, good natural ventilation system as well as a concrete base and inclined surface was designed and constructed using locally available materials. Fresh poultry manure was collected from a major private poultry farm in Ibadan municipality. Fresh cow dung was collected from the Teaching and Research Farm of the University of Ibadan. The sewage sludge used for this experiment was collected from the sewage treatment plant of the University. The cassava peels used for this experiment were collected in bags from a major cassava processing center at Onipepeye area of Ibadan. The cassava peels were air dried for one week at ambient temperature of between $27^0$ and $31^0$C and chopped by pounding in other to achieve smaller particle size which is important for microbial activity and air flow in the compost pile. Fresh elephant grass clippings were cut and collected from an unused land. The clippings act as inoculants in the composting process. Carbon to nitrogen levels of materials to be used were considered before starting the experiment and when developing composting formulas. The initial carbon, nitrogen, moisture content, bulky density, and pH concentrations of cassava peels, poultry manure, cowdung, sewage sludge and grass clipping were determined. Initially, the composting ingredients were arranged in layers such that the supplements were placed on the floor of the compost bins, followed by layer of the grass clippings. The chopped cassava peels were then arranged on the grass clipping and it continues in that trend until all the measured ingredients were exhausted. This orderly loading of ingredients is for efficient composting process. The first treatment (A), was prepared by mixing cassava peels (bulking material) with sewage sludge and grass clippings in a ratio of 1:1:1 by weight. The second treatment (B), has cassava peels, poultry manure and grass clippings in a ratio of 1:1:1 by weight. The third treatment (C), has a blend of cassava peels with cowdung and grass clippings in a ratio of 1:1.5:0.5. The fourth treatment (control) has a mix of cassava peels with grass clippings in a ratio of 1.5:1.5 by weight. The procedures on computing the C/N ratios for the various piles was similar to that recommended by Yaghmaeian *et. al.,* (2005). Each compost bin was designed to contain the same weight of the total materials in the completed mix and to maximize the use of cassava peels while maintaining a C/N ratio of 25 to 35 for rapid compost in treatments as recommended by World Bank, (1987) and Landreth and Rebers, (1996). A net was used to cover the compost bins to prevent bleeding of flies while maintaining optimum passive ventilation system. On weekly basis, the composts were manually turned with a shovel which stands as a passive aeration measure and water was added to raise the moisture content to between 40 and 65% in order to facilitate microbial activity as recommended by Seyedbagheri, (2010). The compost was manually turned with a shovel once a week, and samples were collected for analyses of pH, moisture content, total organic matter, organic carbon, total nitrogen, bulk density (loose), Na, P, K, volatile solids, total aerobic count, total coliform count and total fungal count. Each analysis was conducted on materials randomly from the compost matrix, and provided a general representation of the compost in the reactor.

## RESULTS AND DISCUSSION

### Initial Properties of Composting Substrates

Results from the analysis indicated a low C/N ratio of poultry manure, sewage sludge and cowdung relative to that of cassava peels and grass clippings and was in conformity within the range reported by Michel et. al., (2005), Adegunloye et. al., (2007), Kamolmanit and Reungsang (2007), and Ogunwande et. al., (2008). Table 1 shows the initial properties of materials used for the composting process. Some of the supplements had low carbon to nitrogen ratio when compared with carbon to nitrogen ratio of 25 to 35 required for rapid composting. This warranted the need to add cassava peels to increase the carbon to nitrogen ratio to the desired level for this study. It was noticed that the loose bulk densities of sewage sludge, cowdung, and poultry manure were relatively high and consequently led to the usage of grass clipping to increase the porosity.

### Temperation Profiles

The rise and fall in temperate in the composts (A, B, and C) were very similar as the results shown in Fig. 1. Rapid increase in temperature was observed from ambient to thermorphilic (slightly higher than $47^0$C) within the first 7days and afterwards slightly decreased to approximately $46^0$ C after the first turning event for about 3days until day 15(next turning period). Kamolmanit and Reungsang (2007) reported similar experience when this period was within the first 40 days. Results of the ANOVA revealed that C:N ratio had significant ($P<0.05$) effect on each pile. On the contrary, compost D (control) was at mesophilic stage (30-$33^0$C) within the first 7days, and then decreased and later maintained a relatively stable state until maturity. The undulating temperature pattern indicated in Fig. 1 were as a result of the slight increase in temperature after every turning exercise and are in conformity with previous research work. The interaction between C:N ratio and temperature was not significant ($P>0.05$) during the last three days of composting.

**Table 1: Initial properties of materials used for the composting process**

| Ingredients | Moisture Content (%) | Total Nitrogen (%) | Total Organic Carbon(%) | C/N Ratio | Volatile Solids(%) | Bulk density(g/cm$^3$) |
|---|---|---|---|---|---|---|
| Cassava peels | 27.2 | 0.9 | 43.6 | 49.0 | 1.6 | 0.2511 |
| Sewage Sludge | 63.1 | 1.6 | 23.1 | 14.8 | 2.8 | 1.7325 |
| Cowdung | 52.2 | 0.9 | 23.3 | 25.6 | 3.0 | 1.3653 |
| Poultry Manure | 49.6 | 1.2 | 24.1 | 20.1 | 4.2 | 1.5318 |
| Grass Clippings | 7.6 | 0.9 | 36.2 | 40.2 | 0.4 | 0.0992 |

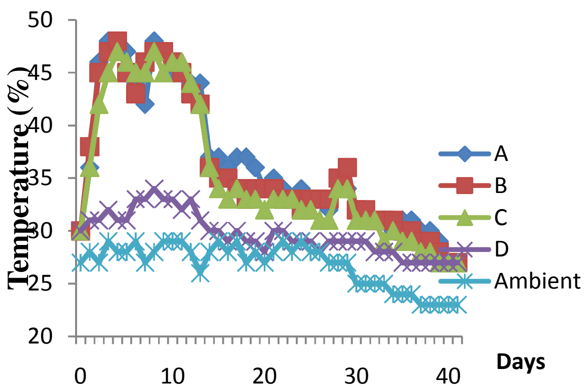


**Figure 1: Daily mean temperature of composting piles**

## pH

Week negative corrections [pile A,(r = -0.495), pile B, (r = -0.655), pile C, (r = -0.551), pile D, (r = -0.516) ] were observed between total organic carbon and pH level. This implies that total organic carbon loss may not be a good factor to determine the pH level. The initial fall and later rise of the pH level as showed in Fig. 2 could be attributed to the generation of large amount of organic acids by microbes when the easily degradable materials have been exhausted and due to the production of ammonium from the ammonification process respectively. This is in line with observations reported by Huang et al., (2004) and Meunchang *et. al.,* (2005). With the exception of pile A, the other piles fall within the acceptable range of 7.5-8.0 as recommended by USDA-NRCS, (2000). The degradation process affected ($p>0.05$) pH change and there was significant effect of pH on all treatment ($p<0.05$).

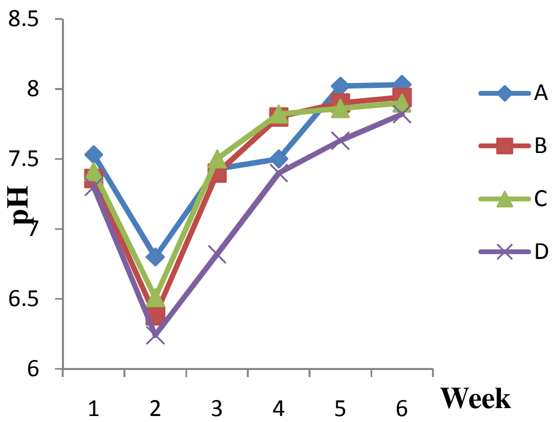


**Figure 2: Weekly variation of pH.**

**Moisture Content**

The initial moisture content falls within 40-65% (Fig 3) as recommended by Seyedbagheri, (2010). The initial gradual increase in moisture content through the addition of water was responsible for rise in temperature observed during the second week. Moisture content of piles A, B, C and D dropped to 47.8, 50.1, 47.4, and 51.1% respectively during the third week may be due to relatively high temperature which vaporizes water, thereby causing the drying of the composting as observed in a previous study (Finstein, *et. al.,* 1992). Thereafter, the subsequent reduction of water added during each turning event resulted in moisture content of piles A, B, C, and D to attain 38, 37, 38.8 and 38.5% respectively. These were within the moisture level for slow microbial activity and matured compost. The result of ANOVA revealed that moisture content during the last 2 weeks was not significantly different ($p>0.05$) and therefore should not have any effect on the composting maturity as observed Bass et al., (2002) and Richard and Walker, (1999).

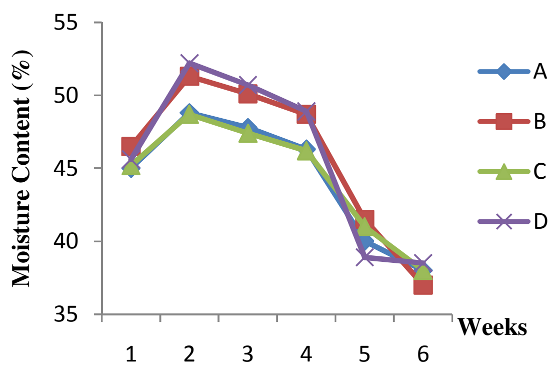


**Figure 3: Weekly variation in moisture content.**

**Total Nitrogen**

Results of ANOVA revealed that the total nitrogen increased significantly ($p<0.05$) as composting time increased. Strong negative correlations [pile A, ($r = -0.974$), pile B, ($r = -0.993$), pile C, ($r = -0.969$), and pile D, ($r = -0.934$)] were observed between total nitrogen and total organic carbon. This implies that as the total organic carbon is reducing the total nitrogen is increasing. Increase in total nitrogen were 56.4, 44.6, 43.4

and 37.3% of their initial values for piles A, B, C, and D respectively. Over 50% of the total increment occurred within the first two weeks (Fig 4) and this coincided with peak moisture and temperature. This sharp increment may be probably due to early conversion of organic carbon to carbon dioxide by microorganisms. Tiqui *et. al.,* (1996) reported that increases in total nitrogen content during composting was probably due to the net loss of dry mass in terms of carbondioxide and water evaporation by microorganisms. The lowest increment as observed during the fourth and six weeks of composting may be attributed to the low temperature and moisture content, and exhausted organic carbon leading to partially dead microorganisms. Huang *et. al.,* (2004) observed increases in total nitrogen in the later stage of composting due to the contribution by nitrogen fixing bacteria in that stage of composting. This leads credence to Huang *et. al,* (2004) observation.

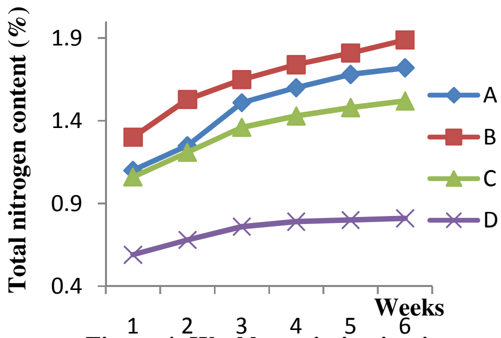


**Figure 4: Weekly variation in nitrogen content.**

## Organic Carbon

The degradation process during composting affected ($p<0.05$) total organic carbon and there was significant effect of nitrogen on all treatments. Decrease in carbon content with respect to piles A, B, C and D amounted to 32%, 23.6%, 25%.8 and 21.6% of their respective initial carbon content. Pile D recorded the lowest quantity of total organic loss probably due to high lignin content and high C/N ration which tend to slow down decomposition processes (Huang *et. al.,* (2004). The sharp decrease in organic content (Fig 5) during the first three weeks proved that the various substrates used had a high proportion of easily degradable organic matter and a large quantity of microbial population. This is in conformity with Gautam *et. al.,* (2010) observation.

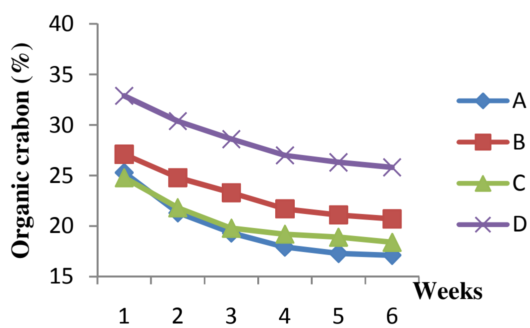


**Figure 5: Weekly variation of organic carbon.**

## Changes in C/N ratio

Result of ANOVA revealed that the C/N ratio of all piles was significant ($p<0.05$) and therefore had effect on the progress of the composting process. C/N ratio of all piles decreased with an increase in composting time (Fig 6). This is probably due to high conversion of organic carbon to carbondioxide as opposed to increase in total nitrogen content caused by nitrogen fixing bacterial. This is contrary to previous study (Ogunwande *et. al.,* 2008). The total decrease amounted to 67.9%, 68.7%, and 67.3% of their initial mixing C/N ratio in piles A, B, and C respectively. However, pile D recorded the least reduction at the end of the 42days composting period. This suggests a lower decomposition rate despite the large amount of grass clippings which ought to inoculate the process. Seyedbagheri, (2010) suggested a favorable C/N ratio of 25 - 30 for the composting of most organic materials while C/N of 20 or below was recommended for a mature compost. (Land Development Department, 2005).

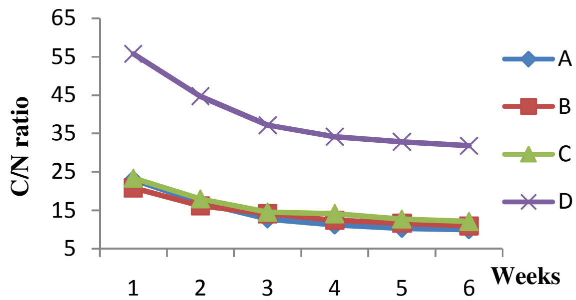

**Figure 6: Weekly varaiation of C/N ratio**

**Total Phosphorus as Phosphate.**

Strong negative correlations of [pile A, (r = -0.960), pile B, (r = -0.925), pile C, (r = -0.947), pile D, (r = -0.930) exist between total organic carbon and total phosphorus as phosphate. This implies that as total organic carbon is reducing, the phosphorus as phosphate is increasing. The increase in phosphorus content might not be unconnected with the phosphorus acid that was produced in the cause of decomposition of substrates used as supplements. This is in conformity with Huang *et. al.,* (2004) observation but contrary to Sridhar *et. al.,* (1985) and Sangodoyin and Akintola (2004) studies. The contradiction with respect to phosphorus trend as observed by previous investigators could be due to relatively low moisture content which tend to completely eliminate phosphate loss in form of leachate. The final amount of phosphorus as phosphate (0.097-0.15%) (Fig. 7) was found to be within the acceptable limits as prescribed for soil conditioning (Paul and Jessie, 1997; Taiwo and Oso, 2004).

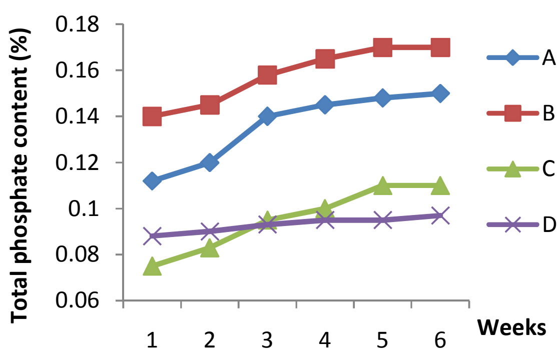

**Figure 7: Weekly variation of total phosphate**

**Potassium**

Degradation process affected ($p<0.05$) potassium content and there was significant effect of potassium on all treatments. Strong negative correlations exist [pile A, (r = -0.960), pile B, (r = -0.982), pile C, (r = -0.950), pile D, (r = 0.954) between total organic carbon and total potassium. The increase in potassium content with respect to piles A, B, C, and D which amounted to 71.1, 26.7, 41.7 and 50% of their respective initial values (Fig.8) could be probably due to the corresponding net loss of carbon as $CO_2$. This is in close agreement with Tiquia *et. al.,* (1996) and Kamolmanit and Reungsang (2007) who reported that total potassium increased with the composting time. The high K content in pile A could be due to higher total K content in poultry manure which contained approximately one third by weight of the total weight of pile A at the mixing stage.

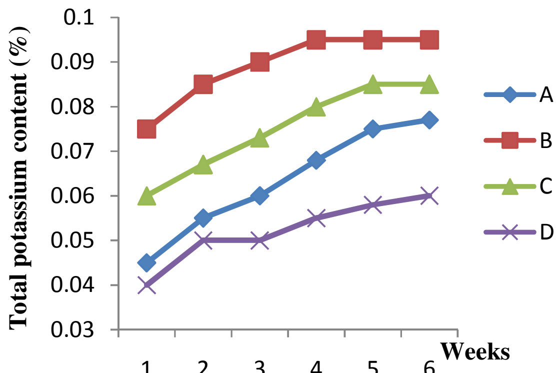


**Figure 8: Weekly variation of total patassium.**

**Sodium.**

Result of ANOVA revealed that the sodium content increased significantly ($p<0.05$) as composting time increased. Strong negative correlations [pile A, (r = -0.950), pile B, (r = -0.969), pile C, (r = -0.0932), pile D, (r = 0.963) exist between total organic carbon and total sodium. The reason for the increase may not be far from the contribution effect of the net loss of carbon as $CO_2$. The increase of pile A, B, C, and D amounted to approximately 11.1, 9.7, 9.8, and 17.9 % of their initial respectively values.(Fig.9) However, the sodium content in all piles was less than the acceptable limits for good compost (Paul and Jessie, 1997; Taiwo and Oso, 2004).

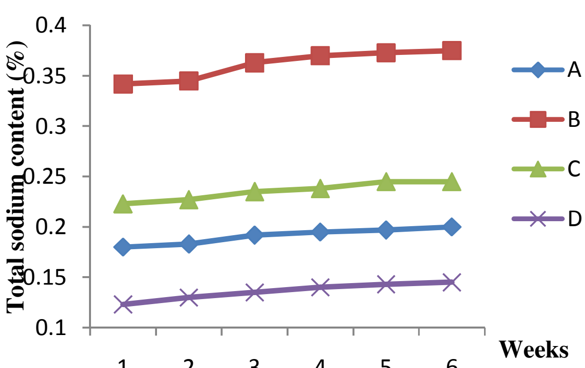


**Figure 9: Weekly variation of total sodium.**

**Calcium**

Gradual increase in calcium content was observed throughout the composting period (Fig. 10). Degradation process during composting had a significant ($p<0.05$) effect on calcium content. Strong negative correlations were observed [pile A, (r = 0.981, pile B, (r = -0.998), pile C, (r = -0.957), pile D, (r = -0.883) between total organic carbon and total calcium content. The increase with respect to piles A, B, C, and D which amounted to approximately 28.1, 13.5, 16.3, and 28.5% of their respectively initial values may be linked with the net loss of carbon as $CO_2$. This increase was confirmed by the findings of Das *et. al.,* (2002) and Adewumi *et. al.,* (2005).

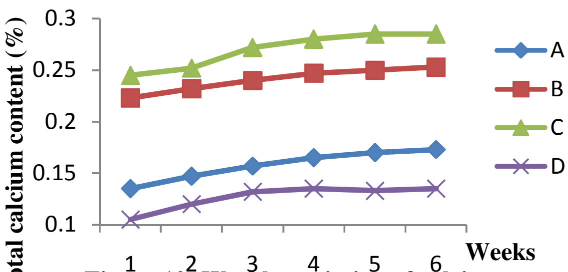


**Figure 10: Weekly variation of calcium**

**Magnesium**

Correction analysis showed strong negative correlations [pile A, (r = -0.951), pile B, (r = -0.957), pile C, (r = -0.976), pile D, (r = -0.957)] between total organic carbon and total Mg content. Results of ANOVA revealed that the Mg content increased significantly ($p<0.05$) as composting time increased. The increase could be as a result of conversion of organic carbon to $CO_2$ by microbial activities. The increase in piles A, B, C, and D were 52, 50, 27.3, and 94.4% respectively(Fig.11).

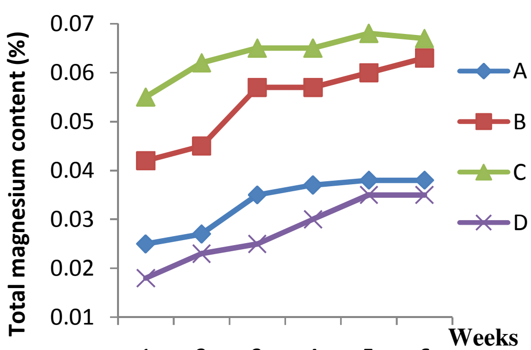


**Figure 11: Weekly variation of magnesium**

**Organic Matter**

Organic matter in all piles decreased significantly ($p<0.05$) as composting time increased (Fig. 12). Strong positive correlations [pile A (r = 0.998), pile B (r = 0.963), pile C (r = 0.993), and pile D (r = 0.829)] between organic matter and total organic carbon was observed. The sharp initial decreased in total organic matter might not be unconnected with easy degradation that occurred at the initial high temperature when the microbial population was maximum (Zhu *et. al.,* 2004). However, a near to stabilization that occurred towards the end of composting might be due to high rate of reduction of most microbes. The slow reduction of organic matter in pile D might be connected with high C/N ratio which tend to slow down decomposition processes (Michel *et. al.,* 2005) or probably due to large amount of lignin content in the mix (Salano *et. al.,* 2001).

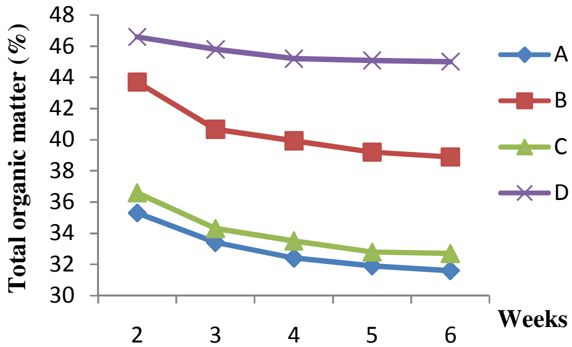


**Figure 12: Weekly variation of total organic matter.**

**Pathogen Reduction**

In this study, presence of *E.coli* (pseudomonas species (sp), aeromanas sp., proteus sp., and enterobacter sp.,) and total fungal count (penicilium

**Table 2a: *E. coli* population (cuf/g)**

| Week | A | B | C | D |
|---|---|---|---|---|
| 1 | $7.2 X 10^5$ | $3.5 X 10^6$ | $7 X 10^6$ | $3.7 X 10^5$ |
| 2 | $5.9 X 10^5$ | $9.1 X 10^5$ | 1.1 X 106 | $3.1 X 10^4$ |
| 3 | $8.4 X 10^4$ | $6.8 X 10^4$ | $5 X 10^5$ | 2.8 X 104 |
| 4 | $4 X 10^4$ | $3 X 10^4$ | $8.6 X 10^4$ | $2.6 X 10^4$ |
| 5 | $3 X 10^4$ | $1.9 X 10^4$ | 4.3 X 104 | $2.5 X 10^4$ |
| 6 | $2.4 X 10^4$ | $1.2 X 10^4$ | $3.0 X 10^4$ | $2.7 X 10^4$ |

**Table 2b: Fungal population (cuf/g)**

| Week | A | B | C | D |
|---|---|---|---|---|
| 1 | $4.6 X 10^6$ | $2.1 X 10^6$ | $9 X 10^6$ | $3.2 X 10^5$ |
| 2 | $3.2 X 10^5$ | $6.6 X 10^5$ | $5.7 X 10^6$ | $8.5 X 10^4$ |
| 3 | $2.8 X 10^4$ | $3.1 X 10^4$ | $4.2 X 10^5$ | $5.1 X 10^4$ |
| 4 | $2.0 X 10^4$ | $2.7 X 10^4$ | $1.3 X 10^5$ | $2.8 X 10^4$ |
| 5 | $2.6 X 10^4$ | $3.4 X 10^4$ | $7 X 10^4$ | $2.4 X 10^4$ |
| 6 | $2.3 X 10^4$ | $2.9 X 10^4$ | $5X 10^4$ | $2.5 X 10^4$ |

sp., candida sp., geotricum sp., aspergillus sp., and rhizopus sp.), total aerobic count (bacillus sp., proteus sp., pseudomonas sp., micrococcus sp., and flavobacterium sp.)

were considered in all piles during composting. *E. coli* increases as composting time increases and the decrease with respect to piles A, B, C, and D amounted to approximately 96.7%, 99.3%, 99.5% and 92.7% of their initial respective values. Moreso, at the end of composting E. coli values fall within the USEPA limits of less than 3 x $10^4$ (cfu/g). There were progressive reductions in total fungal count for piles A, B, C, and D amounting to approximately 99.5, 98.6, 99.4 and 92.2% of their respective values. The rise and fall of the total fungal count (pencillium, aspergillum, candida, geotricum, and rhizopus) was probably due to varying nutrient levels and other environmental factors of the compost such as temperature, aeration and moisture.

**Compost Maturity and Stability.**

About 41 days maturity time was observed which was less than 10 weeks (Das *et al.,* 2002), 49 days ( Zhu *et. al.,* 2004), and 87 days (Ogunwande *et. al.,* 2008) from previous studies. Similarly the maturity time was less than 42 days ( Kamolmanit and Reungsang, 2007), and greater than 21 days (Sangodoyin and Akintola, 2004). Physical characteristics that are suggestive of mature compost include a dark brown to black color with a soil like odour. Virtually all these characteristics were observed in the finished compost with the exception of pile D. It was very difficult to ascertain which compost got to maturity before others, but based on temperature readings and C/N ratio, pile B matured slightly earlier than piles A and C while the control (pile D) took a longer time to mature probably due to slow rate of decomposition.

## CONCLUSION

The poultry manure, sewage sludge and cowdung supplements introduced more nitrogen content in the compost, reduced the C/N ratio and facilitated the composting process by creating appropriate environment for microbes to strive. There were significant correlations between TOC and total N, K, $PO_4$, TOM, Na, Mg and Ca concentrations and composting period. At the latter end of composting process near constant values of these parameters were observed. The poultry manure induced the early maturity of the composting than that of cowdung and sewage sludge and contributed to the nutritional content of compost. The use of the various supplements did not have significant effect in *E. coli* reduction, since virtually all treatments fall within the recommended limit.

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