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Effect of Sawdust and Grass Clippings as Bulking Materials on the Quality of Compost

[1]Prempeh, K., [2]Fei-Baffoe, B., [3]Lawson, B. W.
[1,3]*Department of Environmental Science, GCUC, Kumasi;*
[2]*Department of Theoretical and Applied Biology, KNUST, Kumasi*
* *Corresponding Author: nanaprems@yahoo.com*

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ABSTRACT
The increase in student population has led to a corresponding increase in the generation of waste on the Campus of the Kwame Nkrumah University of Science and Technology. Composting of the biodegradable portion of waste is seen as a better option to reduce the volume of waste and manage it at the same time. This study hence aimed to investigate the effect of some bulking materials on the quality of compost after the decomposition of the biodegradable portion of the waste generated. Bin composting was employed for this analysis. Composting was conducted over a 60 -day period at the sewage treatment plant on the KNUST Campus. Wastes comprising of food waste, sawdust, and grass clippings were mixed in ratios of 1:1, 1:2, and 2:1 (v/v) ratio for sawdust/food waste (SSD 1:1, SSD 1:2, SSD 2:1) and grass clipping/food waste (SGC 1:1, SGC 1:2, SGC 2:1). Turning of compost was done manually at three days interval during which the volume was also recorded. Temperatures were taken on daily basis, three times within a day at 8 am, 12 pm and 4 pm respectively. Volume of all bins reduced as percentage organic matter decreased leading to an increase in percentage ash to between 39. % and 64.5 %. Percent organic matter loss was highest in the grass clipping/food waste treatments compared to the sawdust/food waste treatments. By the end of eight weeks of analysis, the grass clipping/food (SGC 1:1, SGC 1:2, and SGC 2:1) waste formulations were seen to decompose faster than the sawdust/food (SSD 1:1, SSD 1:2, and SSD 2:1) waste formulation. The grass clipping/food waste ratios (especially the SGC 2:1) therefore gave better compost in terms of the quality since rate of decomposition was faster compared to the sawdust/food waste.

INTRODUCTION

Ghana as a developing country produces a lot of refuse as a result of growth in population, rapid urbanization and industrialization. On average daily waste generation per capita of 0.45 kg, Ghana generates annually about 3.0 million tons of solid waste based on an estimated population of 18 million in which Accra and Kumasi produce about 3,000 tons daily (Mensah and Larbi, 2005).

Nsaful *et al*. (2006) in his analysis of percentage waste composition of four halls of residence on Kwame Nkrumah University of Science and Technology KNUST Campus indicated more than 50 % of waste generated in each hall was organic. Percentage organic composition for each of the four halls were as follows: Unity hall (55.6 %), Independence hall (60.6 %), Africa hall (60.8 %), Queens hall (60.5 %). Fresh grass clippings from the mowing activities on Campus as well as sawdust from the Campus carpentry shop all lie waste and make up a sizeable portion of unused total amount of waste created. All these wastes created on Campus are not pretreated prior to disposal and could also lead to adverse environmental conditions and the spread of diseases. In Ghana for instance, landfills used for waste management are primarily open dumps that have no leachate or gas recovery systems. Mensah and Larbi, (2005) also estimated that throughout the country only about 10 % of solid wastes generated are properly disposed off. Indications show that, incineration is a controversial method of waste disposal, due to impacts such as emission of gaseous matter. Hu and Shy (2001) corroborated this by indicating that flying ashes and other hazardous pollutants like dioxins and furans as well as high cost of skilled labour and spare parts acquisition combine to make incineration expensive and controversial to operate.

Composting on the other hand is more environmentally friendly, less expensive to operate and maintain and is a sustainable means of recycling waste when used as fertilizers and soil conditioners (Epstein, 1997). Massiani and Domeizel (1996) corroborated this by indicating that recycling of organic waste as soil amendments is a useful alternative to incineration, landfill or rubbish dumps. Compost quality reflects the chemical makeup of the given compost. A compost could be mature (i.e., fully composted) but could be of poor quality due to low nutrient levels.

The nutrient value of composts varies widely, depending upon the nature of feedstock composted. If initial material contains grass clippings, weeds, or manure, it would be richer in nitrogen and other nutrients more than mainly straw, litter, dirt or corn stalk sources. The percentage composition of the mineral elements in the finished compost has been indicated by Gotass (1956) in Table 1 which intimates that the nutrient composition varied with the nature of the composting materials.

Table 1: Composition of Mineral Elements in Finished Compost From Food Waste, Straw and Corn Stalks

Substance	Percentage by weight
Organic matter	25 – 50
Carbon	8 – 50
Nitrogen (as N)	0.4 – 3.5
Phosphorous (as P_2O_5)	0.3 – 3.5
Potassium (as K_2O)	0.5 – 1.8
Ash	20 – 65
Calcium (as CaO)	1.5 – 7

Source: Gotass, (1956)

MATERIALS AND METHODS

The experiment included both field work and laboratory analysis. The study area was KNUST, a technical university located in Kumasi, Ghana. The set up for the experiment was done at the sewage treatment plant on the Campus of the University. Refuse consisting of solid organic waste materials such as peels of foodstuff, leaves, green plants, wood, ashes, and twigs was collected from the halls of residence on KNUST campus using large sacks. Sawdust (brown and dry) was collected in sacks from the Campus carpentry shop at the Ayeduase gate. Fresh grass clippings (green and wet) were also collected with the help of labourers who mow lawns on campus.

Twenty one portable wooden containments (boxes) constructed in windrow form with dimensions of (0.7m x 0.9m x 1.6m) were used to hold the raw waste. The waste in each box was stirred at three days interval to effect aerobic decomposition of waste.

Preliminary analysis of the individual substrates indicated C/N ratio of 250:1, 23:1, and 19:1 for sawdust, grass clipping and food waste respectively. Preliminary adjustments were hence made to bring the mixtures of sawdust/food waste and grass clipping/food waste to operate within the optimum standard of C/N ratio and moisture content necessary for efficient and effective composting. The ratios used for the mixing of the sawdust/food waste were 1:1 (1 part of sawdust to 1 part of food waste), 1:2 (1 part of sawdust to 2 parts of food waste), and 2:1 (2 parts of sawdust to 1 part of food waste) all measured in volume by volume. The ratios used for the mixing of the grass clipping/food waste also were 1:1 (1 part of grass clipping to 1 part of food waste), 1:2 (1 part of grass clipping to 2 parts of food waste), and 2:1 (2 parts of grass clipping to 1 part of food waste) all measured in volume by volume.

These results obtained complimented the selection of the 1:1, 1:2, and 2:1 ratios in both mixtures of sawdust/food waste and grass clipping/food waste because they were adequate for an efficient composting process.

PHYSICAL MEASUREMENTS

The volume of each treatment was assessed using a tape measure. Since the length, and breadth, of the containers were known, the volume could be assessed by measuring the height occupied from the base of the container to the level of the waste. Daily temperatures were measured using thermometers attached to a rod.

NUTRIENT ANALYSIS

Sample Preparation

Compost from all the different treatments were collected and labeled according to the ratio of solid waste to the bulking agent. The samples were oven dried at a temperature of 105°C for 24 hours. The dried samples were milled to a powdery form and stored in plain labeled polythene bags prior to analysis. Moisture content, total solids, organic matter content, and ash content were measured using standard laboratory procedure Thompson *et al.* (2000).

STATISTICAL ANALYSIS

One factor (one way) ANOVA was used in making comparisons among all the different compost types and ratios at 95 % confidence limit.

RESULTS AND DISCUSSIONS

Organic Matter and Ash Content

Analysis of organic matter results revealed reduction in all windrows during the entire composting period. There was 32 %, 33 %, 40.1 %, 46 %, 47 %, 48.6 %, and 59.4 % loss of organic matter for SSD 1:1 (1 part of sawdust to 1 part of food waste), SSD 1:2 (1 part of sawdust to 2 parts of food waste), SSD 2:1 (2 parts of sawdust to 1 part of food waste), SGC 1:1 (1 part of grass clipping to 1 part of food waste), SGC 1:2 (1 part of grass clipping to 2 parts of food waste), SGC 2:1(2 parts of grass clipping to 1 part of food waste), and CS (Control, only solid waste)respectively (Figure. 1).

These results were nevertheless contrary to that of Fang *et al.* (1999) who reported only a 9 % loss in percentage organic matter in composting of sewage sludge and sawdust-fly ash. All treatments showed statistical significance at the end of composting (P = 3.35E-05).

The ash content for all seven windrows however increased and also showed a statistical significance at the end of composting (P = 3.35E-05). Hence, it was noticed that as organic matter decreased, ash content increased and at such both exhibited an inverse relationship.

This could be due to the fact that organic matter being the organic fraction of the compost is degradable and lost as volatile carbon dioxide and water. On the other hand the ash content is the inorganic fraction of the compost and as such, as the organic fraction is decomposed, it leads to a corresponding increase of the inorganic fraction.

It was noticed that the percentage ash in SGC 1:1, SGC 1:2, SGC 2:1, and CS were higher than that of SSD 1:1, SSD 1:2, and SSD 2:1 due to the fact that the percentage loss of organic matter was higher in the former than the latter and hence led to a bigger increase in the quantity of the inorganic fraction (percentage ash) in the former than the latter.

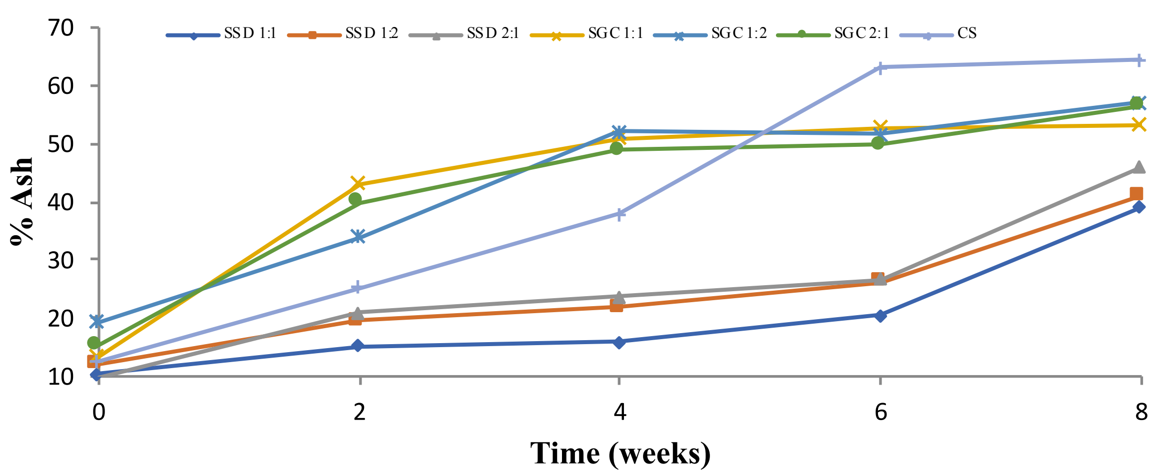

Figure 1: Mean Biweekly Percent Ash of Experimental Treatments.

Figure 1 shows an increasing trend in ash content as organic matter decreased. The increase was from 10.5 %, 12.1 %, 9.8 %, 13.4 %, 19.3 %, 15.4 %, and 12.6 % to 39.1%, 41.1 %, 46 %, 53.2 %, 57.2 %, 56.5 %, and 64.5 % for the treatments SSD 1:1, SSD 1:2, SSD 2:1, SGC 1:1, SGC 1:2, SGC 2:1 and CS respectively as shown.

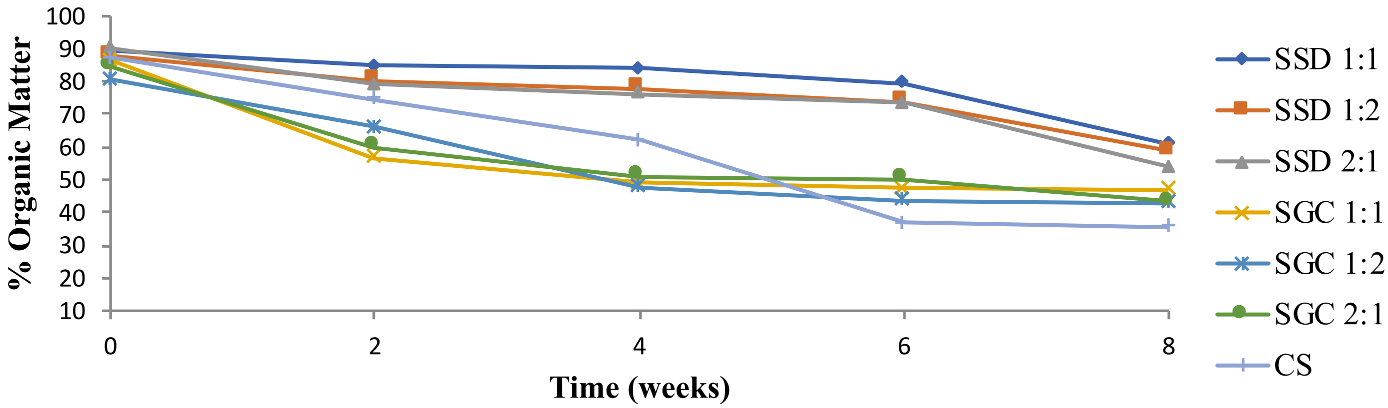

Figure 2: Mean Biweekly Percent Organic Matter of Experimental Treatments.

Figure 2 represents changes in percentage organic matter. Organic matter content decreased from means of 89.5 %, 87.9 %, 90.2 %, 86.6 %, 80.7 %, 84.6 % and 87.4 % to 60.9 %, 58.9 %, 54 %, 46.8 %, 42.8 %, 43.5 %, and 35.5 % for the treatments SSD 1:1, SSD 1:2, SSD 2:1, SGC 1:1, SGC 1:2, SGC 2:1 and CS respectively.

Compost Volume

Results of the volume of compost reduction were statistically significant (P = 5.13E-08). There was 59 %, 73 %, 38 %, 77 %, 77 %, 78 % and 76 % reduction in volume for SSD 1:1, SSD 1:2, SSD 2:1, SGC 1:1, SGC 1:2, SGC 2:1 and CS respectively. The results were in agreement with that of Dao (1999) who reported of over 50 % loss in volume when composting manure. Considerable reduction in volume (over 50 %) was recorded for all treatments except for SSD 2:1 which had quite a minimal reduction of (38 %) and also registered a slower rate of decomposition. This result might be explained by the fact that SSD 2:1 contained a larger proportion of sawdust, which is rich in carbon. Decomposition might have slowed because of the greater resistance to decomposition of remaining carbon compounds (lignin and cellulose) and also due to the minimal availability of moisture which slowed microbial activities and hence the rate of decomposition.

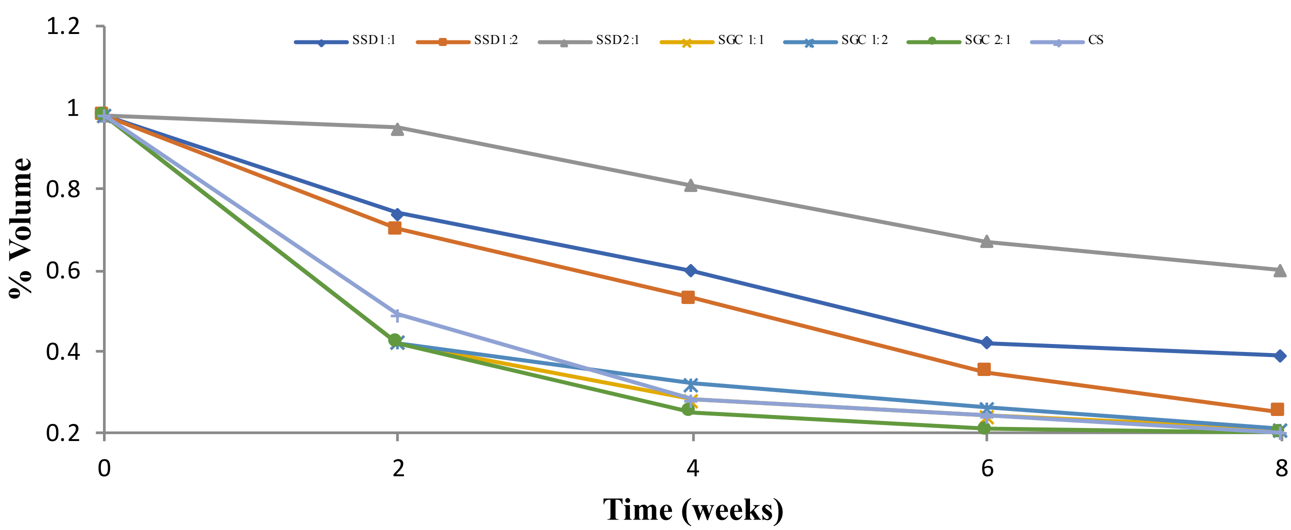

Figure 3: Mean Biweekly Volume of Experimental Treatments

Figure 3 represents the mean biweekly volume changes over the entire composting period from initial values of approximately 0.98 m^3 for all treatments reducing to final values of 0.39 m^3 0.25 m^3, 0.60 m^3, 0.21 m^3, 0.21 m^3, 0.20 m^3, and 0.22 m^3 for the treatments SSD 1:1, SSD 1:2, SSD 2:1, SGC 1:1, SGC 1:2, SGC 2:1 and CS respectively.

Table 2: Mean Values of Parameters Measured for the Treatments at the Beginning of the Composting Process

Parameters	Treatments						
	Mean Value of Parameters						
	SSD1:1	SSD1:2	SSD2:1	SGC1:1	SGC1:2	SGC2:1	CS
C (%)	52.00	51.10	52.40	50.30	46.90	49.20	50.80
N (%)	1.40	1.69	1.31	2.00	1.85	1.90	1.70
C/N	37.14	30.24	40.00	25.15	25.35	25.89	29.59
Ash (%)	10.50	12.10	9.80	13.40	19.30	15.40	12.60
OM (%)	89.50	87.90	90.20	86.60	80.70	84.60	87.40

SSD1:1= (1 part of sawdust to 1 part of food waste)
SSD 1:2 = (1 part of sawdust to 2 parts of food waste)
SSD 2:1 = (2 parts of sawdust to 1 part of food waste) all measured in volume by volume.
SGC 1:1 = (1 part of grass clipping to 1 part of food waste)
SGC 1:2 = (1 part of grass clipping to 2 parts of food waste)
SGC 2:1 = (2 parts of grass clipping to 1 part of food waste) all measured in volume by volume.
CS = Control (only solid waste)
The mean readings for the various parameters at the beginning of the composting process. Table 2 was used to determine the optimum readings before composting.

Table 3: Mean Values of Parameters Measured of Treatments after the Composting Process

Parameters	Treatments						
	Mean Value of Parameters						
	SSD1:1	SSD1:2	SSD2:1	SGC1:1	SGC1:2	SGC2:1	CS
C (%)	35.40	31.40	31.40	26.70	27.10	26.80	25.70
N (%)	1.12	1.15	0.85	2.21	2.19	1.79	1.70
C/N	32.18	27.30	36.94	12.08	12.36	12.73	15.12
Ash (%)	39.10	41.10	46.00	53.20	57.20	56.50	64.50
OM (%)	60.90	58.90	54.00	46.80	42.80	43.50	35.50

SSD1:1= (1 part of sawdust to 1 part of food waste), CS = Control (only solid waste)
SSD 1:2 = (1 part of sawdust to 2 parts of food waste)
SSD 2:1 = (2 parts of sawdust to 1 part of food waste) all measured in volume by volume.
SGC 1:1 = (1 part of grass clipping to 1 part of food waste)
SGC 1:2 = (1 part of grass clipping to 2 parts of food waste)
SGC 2:1 = (2 parts of grass clipping to 1 part of food waste) all measured in volume by volume.
The mean final readings recorded for the various parameters at the end of the composting process. Table 3 was used to determine the quality of compost for each windrow at the end of the composting period.

Table 4: Analysis of Variance of the Biweekly Ash Content of Experimental Treatments

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	5692.298	4	1423.075	9.820861	3.35E-05	2.689628
Within Groups	4347.097	30	144.9032			
Total	10039.4	34				

Significance at $P \leq 5$ %

Table 5: Analysis of Variance of the Biweekly Organic Matter Content of Experimental Treatments

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	5692.298	4	1423.075	9.820861	3.35E-05	2.689628
Within Groups	4347.097	30	144.9032			
Total	10039.4	34				

Significance at $P \leq 5$ %

Table 6: Analysis of Variance of the Biweekly Volume of Experimental Treatments

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2.140246	4	0.535061	19.37625	5.73E-08	2.689628
Within Groups	0.828429	30	0.027614			
Total	2.968674	34				

Significance at $P \leq 5$ %

CONCLUSIONS

C/N ratio reduction occurred more in the grass clipping/food waste ratios than the sawdust/food waste ratios. This showed better and more effective degradation in the grass clipping/food waste ratios than that of the sawdust/food waste.

Volume reduction amongst the grass clipping/food waste ratios was more effective in the 2:1 ratio which comprised of 2 parts of grass clipping to 1 part of the food waste.

The study however revealed that the finished compost for all the ratios of the two different bulking materials were of quality in terms of potassium content as they all had appreciable levels within the acceptable range of 0.5 % to 1.8 %.

Potassium content was highest in the SGC 1:1 ratio which had a percentage of 0.82 %. Phosphorus content was highest in SSD 2:1 (0.31 %) as compared to that of SGC 1:1 (0.30 %), and SGC 2:1 (0.30 %).

From the analyses, the grass clipping/food waste ratios decomposed faster than the sawdust/food waste ratios. This might also have affected the release of nutrients during decomposition.

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