Journal of Occupational Safety and Environmental Health
A Publication of the Society for Occupational Safety and Environmental Health

EFFECT OF COMPOSTING ON TEMPERATURES AND THE TOTAL PLATE COUNT OF ANIMAL AND MUNICIPAL SOLID WASTES

Yahaya, O., Yakubu, S.E., Whong, C.M.Z and Ado, S.A
Department of Microbiology, Ahmadu Bello University, Zaria.
*Corresponding author's e-mail: ocholiahmed@yahoo.com;
GSM: +234(0)8050622272; +234(0)8065308507)

ABSTRACT
Composting is a process of controlled biological decomposition of biodegradable materials under managed conditions that are predominantly aerobic and allow the development of thermophilic temperatures as a result of heat produced biologically. The open pile and the windrow methods were used in composting cow, poultry and municipal solid waste for twelve (12) weeks. The total plate count t and temperature were determined during composting and in the finished products. The results showed a steady weekly decline which stabilizes at week 11 and 12 with 6 and 8 having counts greater than 5.0cfu-g ($\log_{10}$) in the cow waste composted. The mean temperatures of cow waste and poultry waste peaked at 43-7°C and 43.9°C respectively while municipal solid waste was 44.3°C. The results showed no significant differences among the various waste composted ($P > 0.05$; 0.923). The final compost quality met the recommended standard by the European Union for finished compost. Large scale, wide spread and further researches are highly recommended.
Keywords: Solid waste, animal and municipal, composting, plate count, temperature

INTRODUCTION
The development of markets for compost products remains a key challenge to the promotion of a greater uptake of composting. Many countries which have encouraged composting strongly and have put in place a statutory standard supported by systems for quality assurance. Composting relies upon indigenous population of microorganisms from the environment carried by most organic materials and are generally inefficient in trapping energy released during the oxidation of organic substrates. Energy that is not biochemically captured in the catabolic degradation of substrates is dissipated to the environment as heat. This is not normally noticed when the material is spread over a large area of ground. But compost piles restrict the dissipation of heat, leading to an increase in temperature (Zibilske, 1998).

It has been proposed that the attainment and maintenance of a temperature higher than 55°C over a 3-day period should have been sufficient to have eliminated all pathogens. (Anon, 1981) and Strauch (1996) documented the requirements proposed in a number of countries. A list of organisms which could be used as indicators of the efficiency of processing has been proposed (Anon, 2000). Sanitization standards for compost have been developed in the USA (Composting Association of the United States, 1993; Leege and Thompson, 1997; Composting Association of the United States, 2000). The latter have been reviewed recently and specify minimum compost temperatures of 55-65°C for periods of 3 to 14 days depending on the composting process (turned windrow, in-vessel, static aerated piles). A risk assessment of composting treatment to dispose of catering waste containing meat recommended a minimum composting temperature of 60°C for 2 days (Gale, 2002). This was based on the eradication data for a large number of animal pathogens. However, there may be considerable differences in composting temperatures between composting systems of the same 'category' depending on dimensions, airflow and ambient temperature (De Bertoildi *et al*., 1996). The US EPA in "Processing to Further Reduce Pathogens" (Composting Association of the United States, 1993) established criteria for composts made with biosolids. According to the Federal Biosolids Technical Regulations, a windrow must reach a minimum temperature of 55°C for 15 days, with a minimum of 5 turnings. For an in-vessel or static pile system a minimum temperature of 55°C for 3 days is required.

Proper understanding of the quality profiles of compost and their safety determination will not only be significant but also generate the need for the development of simple technique that can be handled by everyone to generate compost whose quality profiles complies with international standards.

MATERIALS AND METHODS

Sampling sites were carefully selected based on the proximity to populace because they are the major receiver of waste, from available cattle ranches and poultry farms and municipal solid waste from and around Zaria metropolis. Municipal solid waste, Cattle waste, Poultry waste (50kg each), of wastes were collected, the waste samples were collected for composting using a shovel and a clean container that can carry up to 50kg of each waste to the composting site (was sufficient for proper composting). Each waste type was composted for 12 weeks each. (Samples were collected on a weekly for the 12 weeks) A total of 432 samples were collected within the said periods. The static aerated piles and windrow methods were used to compost the waste various waste types. It takes between 12 and 20 weeks to complete and consists of forming the mixture of raw materials into long narrow piles or windrows, which are turned and re-mixed on a regular basis. The height of windrows ranges from approximately 1 m for dense materials such as manures to approximately 3.5 m for less dense materials such as leaves.

Temperatures measurements were determined with a mercury-filled Celsius thermometer. The thermometer was immersed in the various wastes long enough to permit accurate and stable reading and the results were recorded. The thermometer was carried along to the sampling sites and readings taken directly from the samples. The temperature values were determined with a Hanna Digital Compo Meter (HI991405, Hanna, UK).

About 25 gm of composting waste sample collected were weighed into 225ml of sterile distilled water (10^{-1}). Samples were serially diluted (10^{-1} to 10^{-6}). The last two dilutions (10^{-5}, 10^{-6} were inoculated in duplicates on the plate count agar (PCA) using the pour plating method. Total bacterial counts were determined after incubation at 37^{0}C for 24 hours (Sikora, 1983).

RESULTS

The weekly mean total plate counts for the various waste types composted (Table1) showed steady decline which stabilizes at week 11 and 12. However between week 6 and 8 cow waste had their counts >5.0 cfu-g (log $_{10}$), poultry waste had their counts above 5.0 cfu-g (log $_{10}$) between week 6 and 9 while municipal solid waste had their count above 5.0 cfu-g (log $_{10}$) between week 7 and 9. The results showed no significant difference between the waste types p>0.05 (0.418, 0.174 respectively) (Figure 1). The different waste types similarly showed lower temperatures at the initial and later part of the composting process (Table 2). The mean temperatures for the cow and poultry waste peaked at 43.7^{o}C and 43.9^{o}C respectively while municipal solid waste was 44.3^{o}C. These peak mean temperatures were achieved at week six (6) for all the compost types after which temperatures dropped steadily to the end of composting. Figure 2 showed no significant differences between the wastes composted (P>0.05, 0.923).

Table 1: Weekly mean total plate counts for the various waste composted (log_{10} cfu-g)

Week	Mean Value		
	Cow	Poultry	Municipal waste
Week 1	9.412	9.437	9.428
Week 2	8.628	8.245	8.449
Week 3	7.732	7.397	7.592
Week 4	6.804	6.603	7.091
Week 5	6.464	6.324	6.829
Week 6	5.833	5.653	6.172
Week 7	5.536	5.507	5.607
Week 8	5.047	5.189	5.367
Week 9	4.951	5.049	5.237
Week 10	4.843	4.767	4.973
Week 11	5.079	5.048	5.198
Week12	5.000	5.075	5.174

The rate of decline showed a significant weekly difference among the various waste types (P<0.05, 0.001) but showed no significant difference between the different waste types p>0.05 (0.418, 0.174) respectively.

Table 2: Weekly mean temperature values for the various waste composted.

Week	Mean Value		
	Cow	Poultry	Municipal waste
Week 1	36.333	36.250	36.625
Week 2	38.750	38.792	38.500
Week 3	41.042	40.375	40.250
Week 4	42.000	41.625	41.417
Week 5	43.083	43.125	43.083
Week 6	44.167	43.958	44.333
Week 7	43.708	43.917	44.167
Week 8	42.750	42.875	42.667
Week 9	40.917	40.625	40.458
Week 10	36.250	38.750	39.000
Week 11	38.000	37.792	37.667
Week12	37.417	37.375	37.292

There was no significant differences between the different waste types composted (P>0.05, 0.923

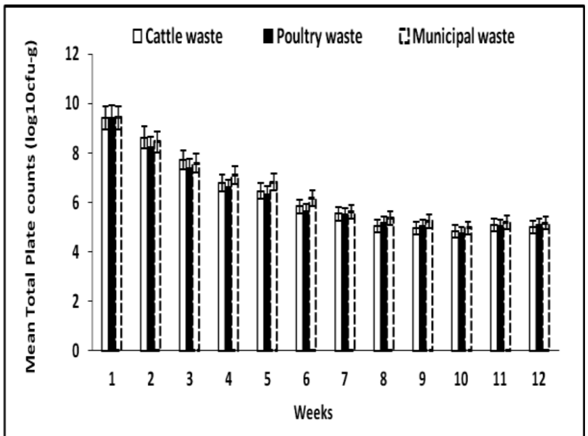

Figure 1. Weekly mean total plate counts for composed wastes

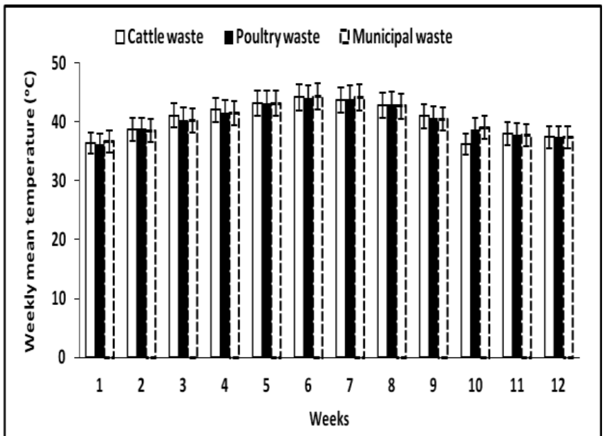

Figure 2. Weekly mean temperatures for composed wastes

DISCUSSION

In this findings, the method of composting did not affect microbial counts (P>0.05). Microbial count were significantly (P<0.05) affected by duration of composting (Table 1). In the open pile and the windrow techniques used in composting the waste, there was an initial increase in microbial count followed by steady decline. The initial increase could be due to the utilization of nutrients by the microorganisms present (Tiquia, 2005). The decrease in count may be due to the depletion of nutrients in the waste, accumulation of toxic products and unfavorable growth environment (Kowalchuk *et al.*, 1999), and Atkinson *et al.* (1996), stressed that the microbial count should be low and should not contain significant quantities of viable pathogenic organisms.

Temperature is the main factor that controls microbial activity during composting. Heating is essential to enable the development of a thermophilic population of microorganisms which is capable of degrading the more recalcitrant compounds (natural and anthropogenic), and to kill pathogens (Boulter *et al.*., 2000). Aeration has an indirect effect on temperature by speeding the rate of decomposition and therefore the rate of heat production. The air requirement depends upon the type of waste (type of material, particle size), the temperature of the compost and the stage of the process. Air supply cannot be controlled by the use of a system used for this composting. Under natural conditions warm air diffuses from the top of the windrow drawing fresh air into the base and sides (Hellmann *et al.*., 1997). Aeration is further encouraged by periodic turning of the windrow. Forced aeration has also been used elsewhere successfully on static piles giving a high degree of process control (Sesay *et al.*., 1997), but in this case the natural process of diffusion was used.

The temperature variation (Table 2) was typical of green waste composting. The thermophilic phase, with temperatures above 45^{o}C lasted for a bit over 3 weeks, during which period temperatures as high as 52 ^{o}C was recorded. After six weeks, the temperature dropped dramatically, reaching ambient levels. Thereafter neither compost turning nor moisture correction resulted to any temperature increase. The compost was slightly alkaline while its electrical conductivity fluctuated and lowered towards the end of composting process.

Microbial activity is influenced strongly by moisture content, activity decreases under dry conditions, and aerobic activity decreases under water-logged conditions due to the resulting decrease in air supply. The recommended optimum water content is 40-60% on a mass basis (Epstein, 1997). There was regular moisturing and turning in this study. Changes in moisture content are related to aeration and temperature, in an aerated static pile system approximately 90% of the heat loss is due to evaporation of water (Sesay *et al.*, 1997). Systems which actively encourage aeration can lead to desiccation and result in a decrease in the rate of decomposition in windrow composting. The compost was kept aerobic to avoid the production of odors. Moisture is essential but if the compost is too wet then anaerobic conditions develop. Anaerobic conditions are also undesirable because of the loss of nitrogen by de-nitrification. There may also be a buildup of organic acids, such as acetic acid, which can be toxic to plants.

According to USEPA (1999) standard, the minimum temperature of 55^{o}C should be maintained for 3 days consecutively, unless the windrow composting is employed. For windrow, a minimum temperature of 55^{o}C for 15 days consecutively should be maintained with a minimum of 5 turning during the high temperature period.

CONCLUSION

A wide range of waste can be composted using the above composting techniques but regulations should place restrictions on the materials that can be used in organic farming and production systems, There is little research specifically on composting in organic farming and production systems, therefore most of the information is based on studies carried out in conventional farming system. However, composting and the use of composted products, e.g. composted manure, forms a major component of soil fertility management in organic farming systems. A large number of pathogenic bacteria and parasites have access to waste materials including those destined for composting. To cause a hazard they must survive the composting process and be able to gain access to their host, either directly or by contaminating pasture or food crops. Composts may also play a role in maintaining the presence of pathogens in the environment where they may be ingested by food animals. This risk is probably less than that presented by the use of human sewage, sewage sludge and animal wastes in agriculture as fertilizers. Most pathogens are efficiently removed during the composting of waste as long as a temperature of 55°C for 3 days is achieved.

REFERENCES

Anon (1981) Technical Bulletin: *Composting processes to stabilize and disinfect municipal sewage sludges.* EPA – 430/9-81-011 US. EPA Office of water program operations, Washington DC 20460 1981.

Atkinson, C. J., Jones, D. D. and Gauthier, J. J. (1996). Biodegradability and microbial activities during composting of poultry litter. *Poultry Science*,75: 608- 617.

Boulter, J. I., Boland, G. J., and Trevors, J. T. (2000). Compost: a study of the development process and end-product potential for suppression of turfgrass disease. *World Journal of Microbiology & Biotechnology*, 16: 115-134.

Composting Association of the United States (1993) *EPA Guideline*, 40 CFR Part 3. Composting Council Fact Sheet, Alexandria, Virginia.

De- Bortoldi, M., Sequi, P., Lemmes, B. and Papi, T (1996). *The science of composting.* Blackie, Glasgow, pp 447-466.

Epstein, E (1997). *The Science of Composting*. Technomic Publishing Company, Lancaster, Pennsylvania, USA.

Gale, P. (2002) *Risk Assessment: Use of composting and biogas treatment to dispose of catering waste containing meat*. DEFRA Report.

Kowalchuk, G. A., Naomenko, Z. S., Derika, P. I., Felske, A., Stephen, J. R. and Arkhipchenko, I. A. (1999). Molecular analysis of ammonia-oxidizing bacteria of the beta subdivision of the class proteobacteria in compost and composted materials. *Applied and Environmental Microbiology*, 65: 396-403**.**

Leege, P.B. and Thompson, W.H. (1997) *Test methods for the examination composting and compost.* The US Composting Council, Bethesda, Maryland, USA.

Sesay, A. A., Lasaridi, K., Stentiford, E., and Budd, T. (1997). Controlled composting of paper sludge using the aerated static pile method. *Compost Science and Utilization*, 5: 82-96.

Sikora, L.J., Ramirez, M and Troeschel, T. (1983) Laboratory composure of simulation studies. *Journal Environmental Quality*, 12: 219-224.

Strauch, D. (1996) *Occurrence of microorganisms pathogenic for man and animals in source separated biowaste and compost – importance, controls, limits, epidemiology*. In "The Science of Composting" Ed. de Bertoldi, M., Sequi, P., Lemmes, B. and Tizano Papi. CEC, Blackie Academic and Professional, London, 224-232.

Tiquia, S. M. (2005). Microbiological parameters as indicators of compost maturity. *Journal of Applied Microbiology*, 99: 816-828.

USEPA (1999). *Control of pathogens and vector attraction in sewage sludge*. EPA/625/R-92/013 Revised October 1999, United States Environmental Protection Agency, Office of Research and Development, National Risk Management Laboratory, Center for Environmental Research Information, Cincinnati, OH.

Zibilske, L. M. (1998). *Composting of organic wastes*. In: D. M. Sylvia, J. F. Fuhrmann, P. G. Hartel and D. A. Zuberer (eds.) *Principles and Applications of Soil Microbiology*. Prentice-Hall, Inc., Upper Saddle River, NJ, US, pp. 482-497.

http://www.sosehnigeria.org