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Research Article

Microbial Quality of Animal Compost using the Windrow and Open Pile Techniques

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Abstract: Composting of raw organic waste is an excellent example of highly biological processes used for agricultural practices. The Open pile and the Windrow methods where used in composting poultry, cow and Municipal solid waste for 12 weeks and the heavy metals in the finished products where determined using the Atomic Absorption Spectrophotometer. The results showed a steady decline in the first seven weeks of composting and the overall quality of the final compost meet the recommended standard by the European Union for finished compost. Large scale, wide spread and further researches are highly recommended.

Keywords: Animal waste, bacteria, composting, municipal solid waste, windrow and open pile

INTRODUCTION

Composting transforms organic matter into a stable product of humus-like substance. The end product can be used for agricultural purposes. Composted raw matter is of various origin including yard waste, manure and Sewage Sludge (SS) and Municipal Solid Waste (MSW).

It is known that soil is a recipient of solid waste which contains enteric pathogens in high concentrations. Gastrointestinal infections are the most common disease caused by enteric bacteria. Some examples are Salmonellosis, Vibriosis, Shigellosis and other infections caused by *Campylobacter jejuni, Yersinia* sp and *E. coli* 0157: H7 and many other strains. Viruses are the most hazardous and have some of the lowest infectious doses of any the enteric pathogens. Hepatitis A, Hepatitis E, Enteric Adenoviruses and Poliovirus type 1 and 2, multiple strains of Echoviruses and Coxsackievirus are associated with waste (Santamaria and Toranzos, 2003). Wichuk and McCartney (2007) advised that since the infective dose for many of these organisms is very low, it is generally accepted that pathogens should be reduced to non-detectable levels and that compost should be maintain at 55°C for at least three days. However, survival of pathogenic bacteria, protozoa and helminthes occurred in a significant number of studies, despite the prescribed time-temperature conditions apparently being met. For example, Strom (1985), Yahaya *et al*. (2011) reported that up to 15 taxas were isolated, including 10 genera, which dominated most samples after composting, the plague causing *Yersinia pestis* was consistently found in static pile compost and a significant increase in bacterial population including *Salmonella, Vibrio* and helminthes in compost was also reported. It has also been reported that *Campylobacter* in cattle manure can survive composting and persist for a long period in the final product (Inglis *et al*., 2010).

The microbial community (biomass) was largest in the run at 40°C, where substantial differences were seen in the microbial community structure and the succession compared to thermophilic temperature (Boulter *et al*., 2000). Although the use of sludge in soil amendment is attractive, it is not without potential health risks, toxic chemicals, including heavy metals and industrial organic waste may enter the food chain and present long-term health risks. Francis *et al*. (2003) reported that the number of coliform count in compost manure from feed lot pen decline as the composting progresses and that *E. coli* was eliminated in the first 7 days when the average windrow temperature range from 33.5°C to 41.5°C. The type bedding did not influence the total plate count or *E. coli* count. However, the total aerobic heterotroph population remains high (>7.0 log 10 cfu dry weights). Scheiff and Dorn (1997) reported that *E. coli* would be cultured from dry poultry (*Gallus gallus domesticus*) manure after 88 days of composting. Cointreau (2003) reported that the number of fecal Streptococci, fecal coliform bacteria and Clostridia count were significant, although counts decline with composting.

The objective of the study is to determine the microbiological qualities and some heavy metals in poultry, cow and municipal solid waste samples.

MATERIALS AND METHODS

Sampling sites: Sampling sites were carefully selected based on the proximity to populace because they are the major receiver of waste, from available cattle ranches

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and poultry farms and municipal solid waste from and around Zaria metropolis.

Collection of waste samples: The types of waste collected and the quantities to be collected are Municipal solid waste, Cattle waste, Poultry waste (50 kg each).

The waste samples were collected for composting using a shovel and a clean container that can carry up to 50 kg of each waste to the composting site (was sufficient for proper composting).

Each waste type was composted for 12 weeks each (Samples were collected from the compost 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. These are open systems which are relatively simple to operate and low cost. There was regular turning and re-mixe on a regular basis.

Sample collection: The composting samples were collected with sterile stainless spoon into a sterile conical flask. These were transported in a cold pack to the laboratory for analysis that will be carried out within 6 h of collection.

Heavy metals: Pb, Ni, Zn, Cd and Cu were determined after digestion of 1 g (dw) of pulverized sample with pure nitric acid, using AAS (Shimazu 6800 Atomic Absorption Spectrophotometer) (Sposito *et al*., 1983).

Sample digestion: The various waste samples (0.5 g) were weighed each into 100cm^3 beakers, a mixture of 5 cm^3 concentrated HNO_3 and 2 cm^3 of $HClO_4$ were added and these were digested on low heat using hot plate until the content was about 2 cm^3. The digest were allowed to cool and then filtered using what man no. 42 filter paper into a 500 cm^3 standard flask. The sieved samples (5 g) each were accurately weighed into a 100 cm^3 beaker and 10 cm^3 concentrated HNO_3 was added to each. The mixture was with a watch glass and refluxed for 45 min. The watch glass was removed and the contents in the beaker were allowed to evaporate to dryness. The aqua-regia 10 cm^3 was added to each sample and evaporated to dryness after 10 cm^3 1M nitric acid was added and the suspension were filtered. The filtrates were then diluted to 50 cm^3 with distilled water in volumetric flask.

Concentrations of Cd, Cu, Pb, Mn and Zn in the samples were determined using the Atomic Absorption Spectrophotometer Model (Shimadzu Double Beam Digital AAS-650) at Department of Chemistry, Ahmadu Bello University, Zaria.

Determination of total bacterial count: Samples were diluted (10^{-1} to 10^{-6}) using serial dilution method. 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 count were determined after incubation at 37°C for 24 h (Sikora *et al*., 1983).

Total coliform count: Total coliform count were determined using EMB (Eosin methylene blue agar). About 25 g of composting waste sample collected were weighed into 225 mL of sterile distilled water and further diluted serially (10^{-1} to 10^{-6}). The last two dilutions were plated out in duplicates using the pour plating method. The plate were incubated at 37°C for 24 h after which the total coliform count were determined (Sikora *et al*., 1983).

RESULTS

A total of 432 samples, 72 from each sets of compost were collected for both microbiological and heavy metal analysis.

Table 1 shows the range of counts, mean and the standard deviation of the total pate and total coliform counts from the six compost analyzed. Comparing the mean of counts, the results showed the mean values for the total pate counts and the total coliform counts, there is a significant reduction in counts between the weeks ($p<0.005$).

The results for the two types of composting techniques used revealed a steady decline in the mean count for total plate and total coliform count up to week 9 and week 8, respectively (Table 2). The indigenous population of total heterotroph mesophilic bacteria in the fresh material was high for the waste composted possibly because the stock piling of the waste which may have allowed decomposition to begin before day 0.

Table 3. Shows the frequency of occurrence of target pathogenic microorganism, characterization and their distribution in the two composting techniques used. A total of 109 suspected *Vibrio*, 152 *E. coli* and 105 *Salmonella* isolates where tested using biochemical and serological test. Out of these number 97 *Vibrio* isolates were confirmed to be *Vibrio cholerae*, 140 where *E. coli* 0157 and 98 were *Salmonella typhi.* From the positive cases, 45 *Vibrio cholerae*, 64 *E. coli* 0157

Table 1: Range of counts, mean and median of the total plate and coli form counts of the compost (log_{10} cfu-g); means with different superscript are significantly different ($p<0.005$) using Duncan's multiple range test

		N	Mean	S.D.
Total-plate-count	Composit1	72	6.01^{a}	1.454
	Composit2	72	5.91^{ab}	1.429
	Composit3	72	6.40^{ab}	1.462
	Composit4	72	6.81^{ab}	1.539
	Composit5	72	6.51^{c}	1.661
	Composit6	72	6.16^{d}	1.489
	Total	432	6.30	1.530
Total-coliform-count	Composit1	72	4.57^{a}	2.583
	Composit2	72	4.60^{b}	2.441
	Composit3	72	5.24^{b}	2.694
	Composit4	72	5.27^{b}	2.190
	Composit5	72	5.62^{b}	2.399
	Composit6	72	$5.0\,0^{c}$	2.034
	Total	432	5.05	2.416

Means with different superscript are significantly different ($p<0.005$) using Duncan's multiple range test

Table 2: Mean and standard deviation of compost for each week counts (log_{10} cfu-g)

Week		Total plate count		Total coli form count	
	N	Mean	S.D.	Mean	S.D.
Week1	72	9.43[a]	0.058	9.41[a]	0.055
Week2	72	8.44[ab]	0.592	8.26b[c]	0.563
Week3	72	7.57[ab]	0.610	7.25[c]	0.740
Week4	72	6.83[ab]	0.825	6.08[d]	0.759
Week5	72	6.54[c]	0.803	5.44[e]	1.330
Week6	72	5.89[d]	0.581	5.14[f]	0.829
Week7	72	5.55[e]	0.481	4.31[f]	1.267
Week8	72	5.20[f]	0.550	3.81[g]	0.854
Week9	72	5.08[g]	0.558	3.14[h]	0.856
Week10	72	4.86[h]	0.179	2.86[i]	0.894
Week11	72	5.11[i]	0.179	2.47[j]	1.234
Week12	72	5.08[j]	0.324	2.44[k]	1.219
Total	864	6.30	1.530	5.05	2.416

Mean with different superscript are significantly different ($p<0.005$) using Duncan's multiple range test (in between groups within the groups) but show no significant differences between the TPC and TCC $p>0.005$ (0.387)

Table 3: Characterization and distribution of isolates from the different compost

Types of isolates	No of isolates tested	Total no of positive isolates	Sources and number of isolates: Open pile	Windrow
Vibrio spp	109	97	54	43
Vibrio cholerae	97	75	45	30
Inaba	-	51	39	12
Ogawa	-	24	06	18
other *Vibrio*	12	12	09	3
E. coli	152	140	64	76
E. coli 0157	140	78	32	46
Salmonella	105	98	47	51

Table 4: The level of heavy metals present in the various compost (ppm

	Lead Conc. S.D.	Cupper Conc. S.D.	Nickel Conc. S.D.	Zinc Conc. S.D.	Cobalt Conc. S.D.	Cadmium Conc. S.D.
MSW	0.507+0.0005	0.438+0.0003	0.156 +0.0008	15.937 +0.0016	0.423 +0.0009	0.013 +0.0005
PW	0.014 +0.0001	0.556 +0.0007	0.062 +0.0005	5.601 +0.0002	0.239 +0.0005	0.002 +0.0002
CW	-0.038+0.0002	0.201+0.0001	0.048 +0.0008	2.054 +0.0005	0.297 +0.0008	0.001 +0.0004

and 47 *Salmonella typhi* where from the open pile methods while 30 *Vibrio cholerae* 76 *E. coli* 0157 and 51 *Salmonella typhi* where from the windrow method of composting.

The concentration of the six heavy metals in the finished compost is shown in Table 4. The mean concentration range for the different types of waste composted are as follows: Pb -0.014 (poultry) -0.05 (MSW), Cu 0.201 (cow) -0.556 (poultry), Ni 0.048 (cow) -0.156 (MSW), Zn 5.601(poultry) -15.937 (MSW), Co 0.239 (poultry) -0.423(MSW), Cd 0.001(Cow) -0.013 (MSW).

The municipal solid waste had a higher value for all the heavy metal tested with Zn having the highest of 15.937 m concentrations (ppm) than the compost from poultry and cow waste.

DISCUSSION

It is a well known fact that biologically processed organic manures are better than inorganic artificial fertilizers. One of the front liners in the world today is environmental protection and waste management. In addition, in Nigeria, governments have encouraged agriculture and local production as against importation. One of the ways to merge these is the conversion of organic wastes to manure for agricultural use. During composting, the microorganisms use the organic matter as a food source. The process produces heat, carbon dioxide, water vapour and humus as a result of growth and activities of microorganisms (Tiquia, 2005). Monitoring of the microbial succession is important in the effective management of the composting process as microorganisms play key roles in the process and the appearance of some microorganisms reflects the quality of maturing compost (Ryckeboer *et al*., 2003).

Microbial count were significantly ($p<0.05$) affected by duration of composting (Table 2). 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). In Nigeria, there are currently no reported values for an acceptable viable microbial count in finished compost. However, Atkinson *et al*. (1996), stressed that the microbial count should be low and should not contain significant quantities of viable pathogenic organisms.

The microbial count of the different compost groups is illustrated in Table 1. The indigenous population of total heterotrophic mesophilic bacteria in the fresh material was fairly high for this type of material, at 3.4×10^9 CFU g-1, possibly due to the gradual collection and stockpiling of the various wastes which may have allowed some decomposition to begin before day 0. The compost was sampled during the all the stages on a weekly bases, thus the possible drop of population at peak temperatures.

The effect of high temperatures exercise on the microbial population is enormous, as high temperatures favor cellulose degradation, bacteria demonstrated a high count at the first few weeks of the study showed their numbers declining steadily (Table 2). This decline could be attributed to the fact that cellulose may become inaccessible to enzymatic attack associated with protective substances such as lignin. During composting, pathogens reduction is accomplished to some degree of several processes, including completion between indigenous microorganisms and pathogens, antagonistic relationship between organisms, the action of antibiotics produced by certain fungi and actinomycetes, natural die-off in compost environment, production of toxic by products such as gaseous ammonia, nutrient depletion and thermal destruction (Hogg *et al*., 2002; Wichuk and McCartney, 2007).

Heavy Metals in composting materials are most times contaminated with potentially toxic heavy metals due to mixture of degradable and non degradable materials. Organic matter often times develop the potentials to absorb these toxic elements when exposed to during refuse collections or plantations in potentially toxic soil which might impact on the final product of composting. The heavy metals in the municipal solid waste composted had the highest concentrations of heavy metals as compared to the other waste composted in this study; this could be attributed to the availability of metal containing waste at the dump sites. The enhanced level of these heavy metals in the solid waste could be attributed to the dumping of plastics, nickel-cadmium batteries, pvc and disposal sludge at the dump sites (Jarup, 2003, Ebong *et al*., 2008).

The heavy metals from the waste could be a feeding source in the soil and such situation could become unsafe when these metals are eventually taken up by plants and subsequently get into the food chain. Ground water could also be threatened by the metal leaches and could make them unfit for human consumption (Leke *et al*., 2011).

In this study heavy metal level was far lower than the standard recommended by the European Union and the UAEPA in the finished products (Table 4). Since compost is designated to be used in the agricultural and horticultural sector, there is considerable concern over the possible heavy metal contamination.

CONCLUSION

In conclusion composting of waste could be the key to achieving the desired reduced reliance on artificial fertilizer and cleaner urban environment. However to make an appreciable difference, there will be need to compost on a large scale and wide spread and further research is needed to quantify the short term benefits of compost use in soil.

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