Journal of Applied Sciences Research 1(3): 292-297, 2005
© 2005, INSInet Publication

Aerobic Composting of Municipal Solid Wastes and Poultry Manure

I.K. Adewumi, M.O. Ogedengbe, [1]J.A. Adepetu and [1]P.O. Aina

Department of Civil Engineering, Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Nigeria.
[1]Department of Soil Science, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria.

Abstract: The management of municipal solid wastes in all cities in Nigeria and most developing countries remain a major public health problem. One possible solution is to separate garbage and other degradable fractions of MSW and process to organic fertilizer. This paper studied the quality and time taken to convert different mix ratio of MSW and poultry manure (PM) into organic fertilizer using the modified Chinese aerobic pole composting method in five boxes each with three unit space volume. The heaps with 70:30 of MSW:PM mix ratio is on the average the same as those of the 60:40 MSW:PM mix ratios. The 70:30 MSW:PM mix ratio was chosen as the optimum mix ratio for the production of organic fertilizer from these two major waste sources.

Key words: Aaerobic composting, municipal solid wastes (MSW), poultry manure

INTRODUCTION

For beneficial management, wastes should be regarded as 'a resource in the wrong place', just as a botanist regards *weed* as 'a plant in the wrong place'. Waste refers to lack of use or value, or 'useless remains'. Waste is a by-product of all human activities. A basic way to deal with waste, therefore, is to restore value to it, at which point it will cease to be a 'waste'.

The lack of value in many cases can be related to the mixed and, in many cases, unknown composition of the waste. Wastes can be classified by a multitude of schemes[1]:

- by physical state (solid. liquid, or gaseous)
- (for solid wastes) by original use(packaging waste, food waste, etc)
- by material type(glass, paper, etc.)
- by physical properties(combustible, compostable, recyclable)
- by origin(domestic, commercial, agricultural, industrial, etc.)
- by safety level(hazardous, non-hazardous).

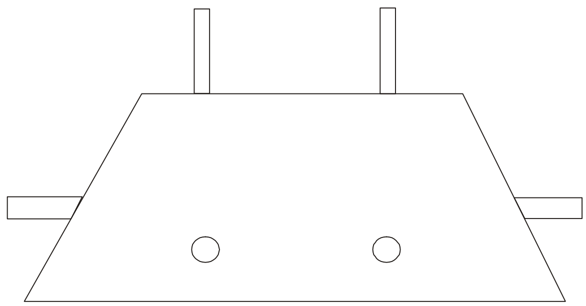
Domestic and commercial wastes are commonly termed municipal solid wastes (MSW) and both account for a relatively small part of the total solid waste stream in developed countries[1] whereas it is the bulk of the waste in Nigeria[2,3].

In order to improve agricultural yield through the use of organic fertilizer and reduce pollution from municipal and livestock wastes, the Federal Government of Nigeria in the recent past commissioned some studies through its National agricultural research Programme (NARP).

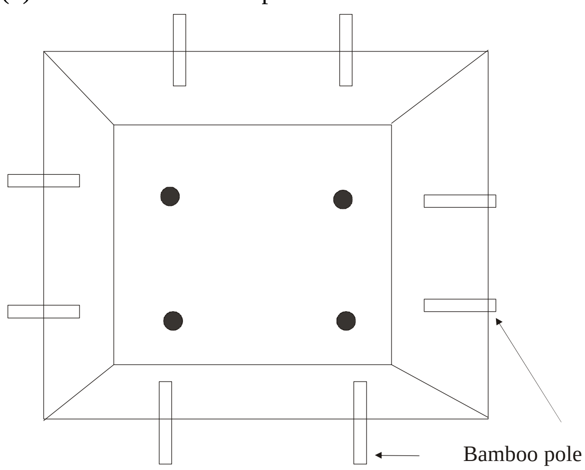
Agricultural research: The first part of our own study was to estimate the quantity, quality and characteristics in Southwestern Nigeria. We established that wastes generated in households in the study area averaged 0.58kg per person-day or 212 kg per person/year whereas the average in Western Europe is 318kg per person/year[3]. About 75 % of MSW ends up in public dumps in the study area. The typical family size is six persons[3]. Major users of public dumps are children in the age range 6 –12 years[2]. Most (79.6 %) of the wastes in the study area are compostable organic materials and are as such of low value. About 74 % of the total wastes generated reached the pubic MSW depot or refuse dump. In developed countries, household wastes represents less than 5% of total solid waste production[1]. Collection of MSW is the most expensive and problematic of all the stages of MSW management in Nigeria as in other countries[2].

Whereas all the methods for treating and disposing of wastes are known to have environmental impacts, the waste must still be treated[1]. What is needed is an overall

Corresponding Author: I.K. Adewumi, Department of Civil Engineering, Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Nigeria.
E-mail: kenadewumi@yahoo.co.uk



(b) side elevation of compost bed



(a) Plan of compost bed
Source: Rybczynski *et al*[6]

Fig. 1: Plan and elevation of the Chinese bamboo poles compost heap.

strategy to manage waste with reduced environmental impact, and at an affordable cost. In undeveloped or developing countries, the managers of MWM facilities neither have accurate cradle to grave data of wastes nor adequate facilities/program for effective management. The first stage of this study showed how a field evaluation approach could be used to establish a baseline data for a lifecycle inventory of MSW. The data is intended for planning a composting plant for converting MSW and poultry manure (PM) into organic fertilizer for the purpose of improving both the soil physical properties and farm yield in Southwestern Nigeria.

Composting is the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, with a final product stable for storage and application to land without adverse environmental impack[4,5]. Composting is not a new technology, especially the Windrow anaerobic composting which process lasts two to three months or the Chinese aerobic mixed substrate composting which has holes through the compost heap and takes 20 –25 days for it to stabilize[6] (Fig.1). Aerobic composting needs proper aeration to provide sufficient oxygen for the aerobic microbes to stabilize the organic wastes using periodic turning of the piles or by insertion of perforated bamboo poles into the compost piles[5]. The optimization of the mix proportion for aerobic composting of MSW and PM using bamboo poles to create aeration passage is the objective of this second stage of that study.

MATERIALS AND METHODS

Twenty randomized grab samples of MSW were each collected on three different days from three to five community dump or depot in eleven cities of the southwestern Nigeria. The randomization is based on extraction from a statistical table of random numbers. The first two digits in each row of five digits were decided to be used in picking the first twenty numbers. Any two digits outside the intended range of values were noted and marked on a sheet of paper as ‘0’ while those intended were recorded as ‘1’. The random selection is then based on the order of the dumper’s arrival at a purposively selected dump or depot.

If three zeros follow one another before a ‘1’, then it is the fourth user that would be sampled. The whole volume of waste brought by such randomly selected user was collected in a plastic bag and sealed. A mark showing location, sample number and time of sampling was put on each sac. Each bag’s content was then weighed and sorted into their physical constituents. The garbage fractions were mixed and three grab samples weighing 100 g ± 2 g each were taken for nitrogen analysis in Kjedal flasks at the Animal Science Laboratory of the Obafemi Awolowo University, Ile-Ife. The inorganic elemental analyses of typical plant macro- and micro- nutrients and common heavy metals (HMs) in the same samples were made using atomic absorption spectrophotometer (AAS) according to Standard Methods[7]. Similar digestion and determination of nitrogen and elemental concentrations in PM were also made.

The University Refuse Collection vehicle was used in collecting garbage from the Ile-Ife Community to the Civil Engineering Building where the garbage in the MSW was sorted manually by project staff. The sorted materials were shredded manually into sizes not larger than 25mm by 25mm in area. A Load of PM was also collected from the University Agricultural Research Farm. Five Composting boxes with three units of 610 mm x 610 mm x 610 mm compartments each were constructed for a scaled-down laboratory analysis to simulate modified Chinese

Fig. 2: The compost boxes being filled with the substrates, the first box (left) shows the bamboo poles in place to create aeration holes.

Fig. 3: The picture shows the boxes already filled, the poles removed and the heaps covered with thick polythene to reduce heat loss.

8-pole aerobic composting process (Figs. 2 and 3).

The MSW and PM were mixed into five treatment units to contain MSW alone, and PM alone as single substrates, and 80:20-MSW/PM, 70:30-MSW/PM, and 60:40-MSW/PM mixed substrates. Practice recommends a garbage-swine manure mix of 60:40[6]. The boxes with appropriate holes to take the voiding poles were marked and filled with the substrates wetted to a moisture content (MC) of between 50 –70 %[5,6]. Rather than using earth cover topsoil extract, containing aerobic microorganisms such as *Aerobacter aerogenes* and other fungi/molds that assist with decay, was used in preparing the substrates.

The mix was rammed around the poles and kept covered for three days with thick polythene sheets. The rods were removed after three days and the holes kept free of blockage. The temperature of the three substrates in each treatment unit was monitored daily and the MC kept within the range specified above and the average value found for each treatment. The monitoring was made daily at about 9.30 a.m ± 30 min until the temperature stabilized to about the ambient air temperature. The digested materials were then each subjected to Kjedal analysis for the nitrogen content using standard methods and to elemental analysis as for the raw materials using standard methods and atomic absorption spectrophotometry[7].

RESULTS AND DISCUSSIONS

Fig 4 shows the mean heap and ambient air temperature curves for each of the five treatments representing the 3 – 5 dump sites in the eleven cities used in the study. Table 1 shows the results of the chemical properties of the raw substrates and the digested materials. By method of dimensional analysis, the temperatures in a full-scale model box of dimensions 1.20m x 1.20m x 1.20m internal dimensions and aeration holes of 100mm diameter both of which are twice those in the laboratory scale model would be higher than observed in the scaled- down model and such high temperature will be sustained for a longer duration than for the 3 - 5 days observed in this work (Fig 4). Such high temperature (above 55° C) for 6-8 days are reported to destroy most pathogenic microorganisms and eggs of common intestinal worms where human fecal wastes are used in composting. Such high temperatures would also destroy microorganisms that may be in the PM and MSW whether of human or animal origin.

The temperature pattern of the mixed substrates showed that the 70:30-MSW/PM and 60:40-MSW/PM mixes had almost the same stabilization progress. The physical conditions of the two products showed that the compost samples are both dark with hardly any difference in texture. The 70:30 mix was therefore chosen as the optimum mix proportion for the MSW and PM in aerobic composting of these two wastes. This is because it will involve the use of more of the MSW and less of the PM.

The elemental analysis as shown in Table 1 showed that the C:N ratio of 25.8 for the 70:30-MSW/PM compost was within the range considered suitable for use as soil conditioner for farming. The N:P:K values of 1.35 %:0.56 %: 1.37 % actually implies about 13.5g/L or 13.5kg/m^3 of nutrient nitrogen, 5.6kg/m^3 of Phosphorus as phosphate, and 13.7 kg/m^3 of potassium are the macronutrient content of the 70:30-MSW:PM mix compost. It may be necessary to add slight amount of mineral fertilizer to improve the activity of the fertilizer. However, the final pH of the compost would reduce the acidity of the soil and reduce the effect of low activity clay (LAC) identified by Adepetu[8,9] as being responsible for poor yield of farm products and high level of erosion of tropical soils.

From the results there was reduction in the concentration of the HMs especially Pb and Cd in the produced compost Part of the ions may have been converted or used up but certainly some parts may have leached from the heap during stabilization. This emphasizes the need for a leachate drain and retention tank in the design of the composting platform and facility. It may be necessary to study the sink for such transit or conversion of the HM.

Now that both MSW and PM, which are major polluters, could be converted to organic fertilizer using the determined optimum mix proportions, sorting of MSW is considered very crucial to a *grave* to *gate* recycling of these wastes. The management proposal requires the zoning of cities into MSW management units in such a way that a treatment facility would be within a quarter or one half of a kilometer from the residences served by the facility.

A refuse sorting machine is considered essential to such facility to remove drudgery and reduce direct contact with the wastes if the MSW were sorted manually. Such sorted materials make the processing of the garbage into compost easier. The remaining valuable materials such as paper, glass culets, plastics, metals, etc may be stored indefinitely until sold out to interested buyers. A preliminary study has shown that people are willing to sort wastes at source providing the collection of the offensive, decomposable garbage could be made within three to four days[2]. Such collection system done within four days would prevent the full developmental cycle of

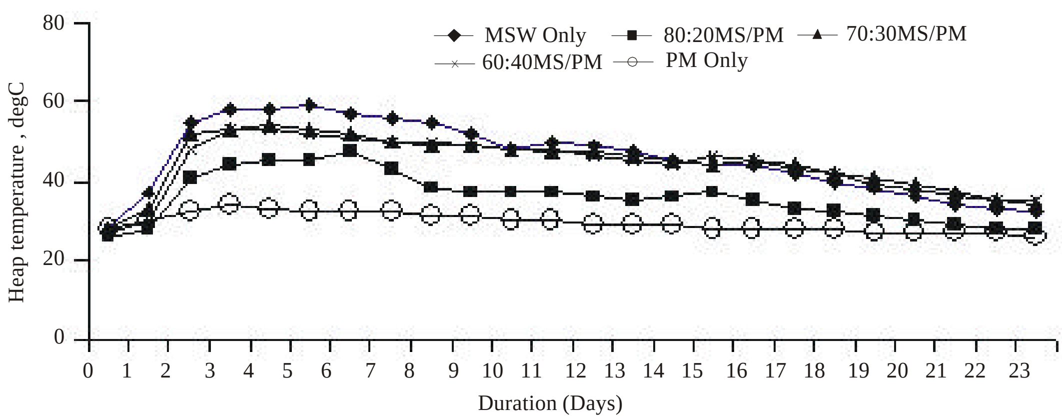


Fig 4: The mean compost heap temperatures of the different mixes of MSW and PM on processing days until stabilization.

Table 1: The mean chemical compositions of MSW, Poultry Manure (PM) from across Southwestern Nigeria and the 70:30 MSW/PM mix compost.

Elements	Municipal Solid Wastes		Poultry Manure	70:30 MSW/PM compost mix
	Range	Mean	Mean	
C [%]	38.2-60.1	44.80	31.70	34.80
N ,,	1.2-2.0	1.32	2.78	1.35
P ,,	0.9-2.3	1.44	0.39	0.56
K ,,	0.28-0.5	0.41	2.20	1.37
Ca	0.32-0.8	0.47	3.82	1.62
Mg	0.07-0.2	0.12	0.43	0.36
Na	0.03-0.1	0.06	0.22	0.24
C:N ratio		34.0	11.4	25.8
Zn (ppm)	109.0-233.7	142.2	585.0	38.21
Cu ,,	9.2-30.1	18.9	52.3	18.80
Fe ,,	906.0-3842.0	2180.0	5335.0	3984.0
Mn ,,	61.7-149.3	106.8	502.2	306.0
Cd ,,	0.8-3.0	1.82	2.4	1.47
Pb ,,	1.6-4.6	2.92	6.1	3.64
Ni ,,	3.1-16.3	5.85	18.2	10.98
pH			8.30	7.76

the eggs of the domestic housefly through the larval and pupal stages to the adult fly, which takes five days in tropical conditions.

The next stage of experimentation would require the use of full-scale 1.20m x 1.20m x 1.20m compost boxes, especially to know the highest temperature reachable in the compost heaps and duration of sustenance of such temperature for the purpose of destroying pathogenic microbes in the wastes. The zoning of the cities into MSW management units would also create jobs for youths in the communities. This approach would also turn MSW management into revenue –generating venture instead of just being a budget column under social services. Producers of storage facilities would also create an income source.

Conclusion: The results in this laboratory scale study showed that solid wastes pollution from MSW and PM could be reduced by conversion into organic fertilizer at a mix ratio of 70:30 of MSW:PM through the process of aerobic composting as presented in this work.

ACKNOWLEDGEMENTS

The authors acknowledge the research grant No NARP- RGS-021 jointly provided by the Nigerian Agricultural Research Programme (NARP) and World Bank.

REFERENCES

1. White, P.R, M. Franke and P. Hindle, 1995. Integrated Solid Waste management: A Lifecycle Inventory, Chapman and Hall, London.
2. Adewumi, I.K. and B.A. Fajewonyomi, 1997. “ Design considerations for Municipal Solid Wastes Silos in developing countries,” Journal of School Health Education, 4(1), 35-44.
3. Adewumi, I., M.O. Ogedengbe and J.A. Adepetu, 1999. “Mechanized Processing of Municipal Wastes for Organic Fertilizer Industry,” Paper presented at the First National Engineering Design Conference, Nigeria Society of Engineers (NSE) /Federal Ministry of Science and Technology, Sheraton Hotels and Towers, Abuja. Sept 26-29. 12pp

4. Haug, R.T., 1980, Compost Engineering: Principles and Practice, Ann Arbor Science, Michigan.
5. Polprasert, C., 1996. Organic waste recycling, 2nd Edn., John Wiley and Sons, Chichester.
6. Rybczynski, W., C. Polprasert and M. McGarry, 1978. Low-Cost Technology Options for Sanitation, IDRC-102e, International Development Research Centre (IDRC), Ottawa
7. American Public Health Association (APHA), 1996. Standard Methods for the Examination of Water and Wastewater 15th Edn., APHA, Washington ,D.C
8. Adepetu, J.A., 1994. “Soil fertility management and sustainable farming system for NALDA projects,” A paper presented at National Lands Development Agency (NALDA) Soil Management Workshop, Minna.
9. Adepetu, J.A., 1997. Soil and Nigerian food security, Inaugural Lecture Series 119, Obafemi Awolowo University, Ile-Ife.