Domestic composting of food waste using small-scale composter

D. V. Vich[1], H. P. Miyamoto[1], C. V. dos Santos[1], L. M. Queiroz[1], V. M. Zanta[1]

[1]Department of Sanitary and Environmental Engineering, Federal University of Bahia, Salvador, Bahia, 40.210-630, Brazil

Email: zanta@ufba.br, +55 71 32829454

Abstract

This research investigates the performance of food waste composting using small-scale domestic composters. Three trials were conducted with compostingfood waste and wood chips (70:30 % wet weight)in 10 liter containers using different feed schemes.In the first trial the composter was fed weekly over two months. Inthe second,the processwasfedonce with a mixture of food waste and 100% of theused wood chipsfrom the previous trial. The last trial was fed with food waste and 50 % of the wood chips used in the second trial and 50 % of new wood chips. The physical chemical parameters were monitored and the total coliforms and *Escherichia coli* were quantified in the compost. The results of the first trial showed that after the last feeding, carbon decreased 40 %.In the second and third trials, carbon decreased 54% and 40%, respectively. Thequantity of composted material with particle sizes lower than 1.2 mmwas small.The compost obtained from the second trialhad a C/N ratio of 16;51% moistureand 7.6pH.The highest number oftotal coliforms was 3.8 x 10^3 MPN/g dry of total coliforms. In conclusion the stabilization of food wasteis possible in a simple composter with food waste and wood chips and the reuse of the wood chips improves the efficiency of the system. Small-scale production of compost can be useful for places with limited space. However, the presence of total coliforms was over the number allowed by the Brazilian Norms andthe nitrogen concentration was below standard, therefore, additional investigation is necessary.

Keywords: domestic composter, food waste, small-scale composter, composting

Introduction

The Brazilian National Solid Waste Policy (BRASIL, 2010)was established recently. The Policy guidelines are related to reduction by reuse, recycling and recovering,and after this, landfilling. The urbansolid waste (USW) corresponds to domestic and small commercial production. InBrazil, the organic fraction of USW presents about 50 % of food and garden waste. One of the strategies for the organic solid waste (OUSW) addressedin theNational Solid Waste Plan (BRASIL, 2012) isthe adoption of domestic composting for reduced organic waste generation.

However,in Brazil,the mainly USW destination, actually, isthe landfilling, followed by the disposal in dumpers. Only 1% of the urban solid waste (USW) is sent to decentralized composting plants (BGSI, 2010). Domestic composting is not acommon practice and there arefew experiences and scientific researches about this process in Brazil.

It is known that the success of the domestic composting depends of the home composter performance and the products quality (Adhikari et al. 2010).Investigations were conducted about domestic composter performance in relation to passive and/or forced aeration, batch and/or semi-continuousfeeding (Papadopoulos, et al. 2009; Huang et al., 2002; Chang et al, 2005; Lin et al. 2008;Kumar et al.; 2009; Karnchanawong et al., 2011). Several small to medium size composters(10–300 L) have been developed andits characteristics have influenced the process.The most important composting process conditions are: carbon and nitrogen ratio between 20 and 40, moisture content between 50 and 65%, adequate aeration, small particle size and adequate mass transfer between air and solids (Chang, et al., 2005).

In this work an exploratory and preliminary study was conducted to investigatethe performance of food waste composting using a small-scale domestic composter in semi-continuous and batch feed, with new and reused wood chips.

Material and methods

Experimental Apparatus

Low cost 10 liters capacity plastic containers, readily available in supermarkets, were usedin this study. The containers were perforated with 0,6 cm diameterholes,corresponding to 4% of the surface areaas shownin Fig.1, to provide natural aeration.

Fig.1. Composters

Composting materials and composter operation

Food waste collected from restaurants and wood chips of ~~the~~ eucalyptuswere used in the three trials. The food wastewas composed by vegetables and fruits. The characteristics of the material are shown in Table 1 and 2.In the second and third trialthe same wood chips from the previous trials were used.

Table 1Food Waste Characteristics

Parameters	Trial. 1				Trial. 2	Trial. 3
	Feeding 1	Feeding 2	Feeding 3	Feeding 4		
Moisture (%)	87.5	87.4	85.3	90.2	82.6	84.1
VS (%)	71.2	78.2	74.0	84.8	94.7	88.1
Carbon (%)	28.8	31.4	31.4	38.5	30.7	34.4
Nitrogen (%)	1.5	2.3	1.5	2.3	1.4	1.0
C:N ratio	19.2	13.7	20.9	16.7	21.9	34.4
pH	5.4	5.0	5.4	5.6	3.6	4.9

Table 2 Bulking Agent (wood chips) Characteristics

Parameters	Trial. 1				Trial 2	Trail. 3	
	Feeding 1	Feeding 2	Feeding 3	Feeding 4	Reused wood chips	New Wood chips	Reused wood chips
Moisture (%)	10.0				42.2	10.0	15.9
VS (%)	99.1				86.5	99.1	85.3
Carbon (%)	28.6				35.8	28.6	37.1
Nitrogen (%)	0.2				0.9	0.2	1.4
C:N ratio	145.3				38.6	145.3	25.8
pH	4.4				6.7	4.4	6.9

The particle size of the food waste wasreduced to 1 cm manually and it was mixed with the woodchipsfor each trial by hand as well. Trial 1 was duplicated. The initial experimental conditions are shown in Table 3 for each trial. In alltrials the ration of food waste and wood chips was always with 70:30 in % wet weight or 0.3:1 in dry weight.

Table 3 Initial conditions of the mixture for each trail

Parameters	Trial.1				Trial. 2	Trial. 3
	Feeding 1	Feeding 2	Feeding 3	Feeding4		
Wet weight (g)	1178.0	1126.0	1641.0	1753.0	3000	3045

Dry matter (g)	420.8	405.5	654.8	690.1	885.6	1112.2
VM (g)	388.3	380.8	611.6	661.7	865.6	1009,8
M (%)	67.6	56.5	61.6	58.2	68.8	67.6
VM (%)	92.0	93.6	93.4	90.3	92.5	93.0
C:N ratio	55	39	42	38	31	39
pH	5.2	6.4	6.6	7.3	4.3	5.7

Observation: VM- Volatile Matter ; M –Moisture; C- Total Carbon; N- Nitrogen

In the first trial, semi continuous operation was used,with feeding on weekly basis, on days 7, 14 and22. The quantitiesput into the composteron each fed were sufficient to fill it. In the second trial the process was not fed. The mixture composed of food waste and 100% of the wood chips from trial 1 with particle size greater than 0.42 mmwere used. In the last trialthe compost was fed with food waste and 50% of the wood chips fromtrial 2 with particle size greater than 0.42 mm,dried at room temperature for one day, and 50 % of newwood chips.

In all the trials manual stirringwas used for aeration. The frequency of the aeration is shown in Table 4.

Table 4 Aeration Frequency user in the trials

Experiment	Frequency
1	Daily
2	Daily in the first week and after this three times a week
3	Daily in the first week and after this once a week

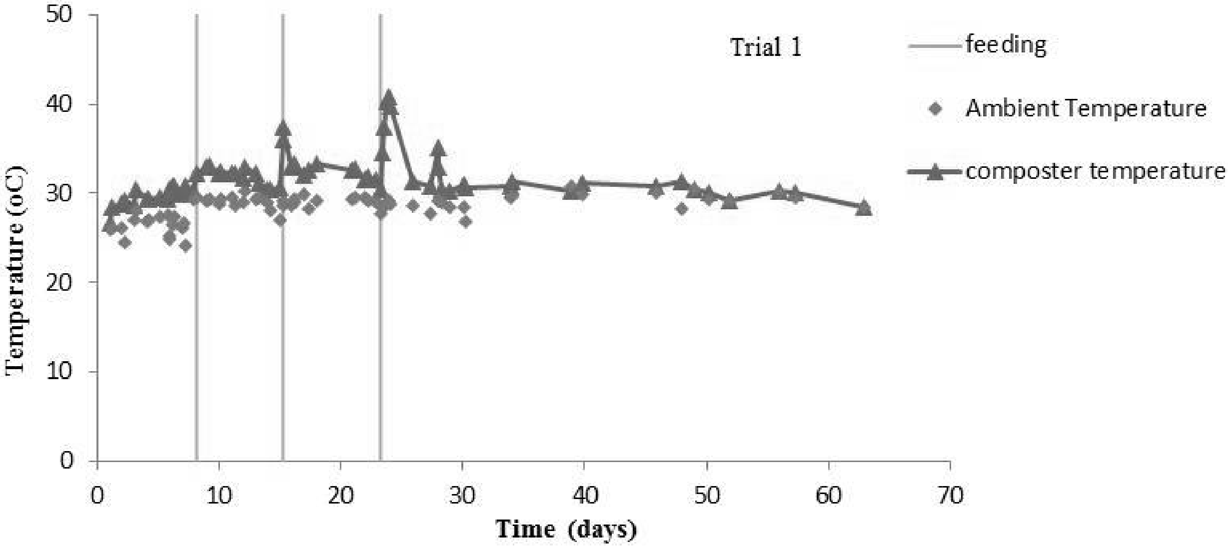
Composting monitoring

Several parameterswere monitored over time: Temperature (T), pH, Moisture (M), Organic Volatile Matter (VM), Total Organic Carbon (C) and Total Nitrogen (N). N and pH values were measured according to Tedesco (1995),M and VM were analyzed according to the*Standard Methods* (APHA, AWWA, WEF, 2012). C was determined using high-temperature solids combustion system (1200°C) using multi N/C®2100 analyzer, *Analytik Jena* andTotal coliforms and *Escherichia coli* were quantified by defined substrate technique using Colilert®, IDEXX.

The quality of the compost was analysed considering reference limits of norms adopted by Brazil's Agriculture Ministry for organic fertilizers class C, which includes raw material originated of domestic waste (Brazil, 2009). This norm states that the compost should have moisture levels lower than 50%, minimum values of pH, C and N should be6.5, 15% and 1% respectively.C/N ratio should be 18 and Thermotolerant coliforms must be below 10^3 MPN/g TS.

Results and discussion

The temperature profile by time isshown in the Figure 2for each trial. In the trial 1, one day aftereach feeding,a temperaturepeak at 33°C, 36°C and 40.3°C occurred. The phase thermophilic (> 45°C) wasnot reached and moistures content wasnot excessive. Probably, the small reactor lost heat for the ambient air. The pattern is a typical self–heating composting(Karnchanawong et al., 2011). The peak temperature in the trial 2 was 46.2°C, but dropped within a day. In the trial 3 was observed a similar pattern. Apparently, the reuse of wood chips in the trial 2 and 3 improved the process. Itis possible to observe that the lack between temperature peaks was longer with batch process without semi continuous feeding. The intervals of time were 5 days in the trial 1 and 10 days in the others trials.



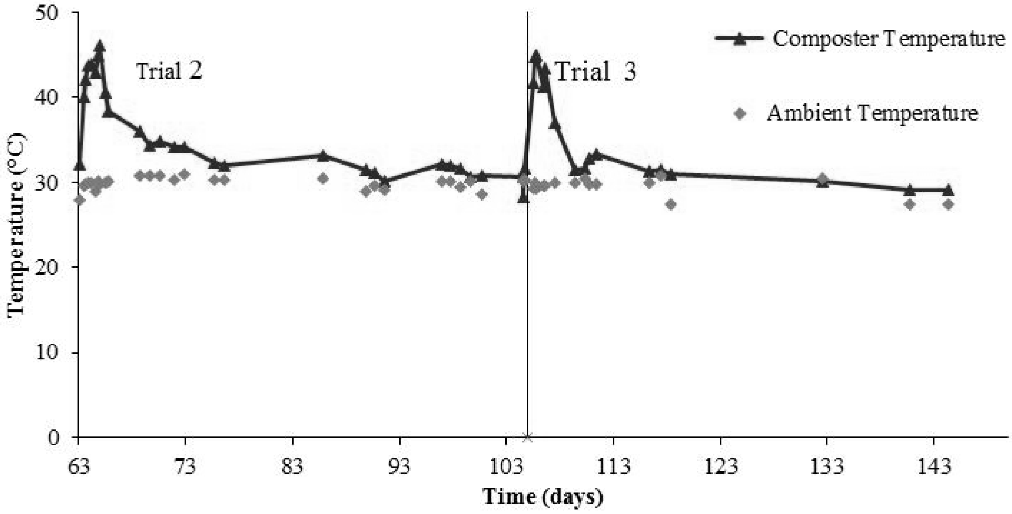


Fig. 2 Temperature profile with time for each trial .

The C/N ratio mixturedecreased in all trials (Table 5). Theend mixture C:N were over the limits for compost quality in Brazil(>18), probably, because of the lower wood chips biodegradability used withbulking agent.

Table 5Initial and end Carbon and Nitrogen ratio of the mixturein the trials

Trial	C:N ratio initial	End C:N ratio
1	55	35
2	30	26
3	39	25

Figure 3(a) shows the moisture decreased below 40 %. In the trial 3, it was used dried reused wood chips and new wood chips to reduce initial moisture of the mixture which seems to improve the conditions of the process. Acidic range pH after feeding was observed and increased to pH value about 7.0. The hydrolysis and organic acids production in the first stage was responsible for the decrease of pH (Chang, 2005). The VM (%) reduced about 60 % in all trials and C(%) reduced

48%,54% and 40% in tria1, 2 and 3, respectively.Possibly, the highest reduction of Carbon in the trial 2 was caused by theuse of reused wood chips.

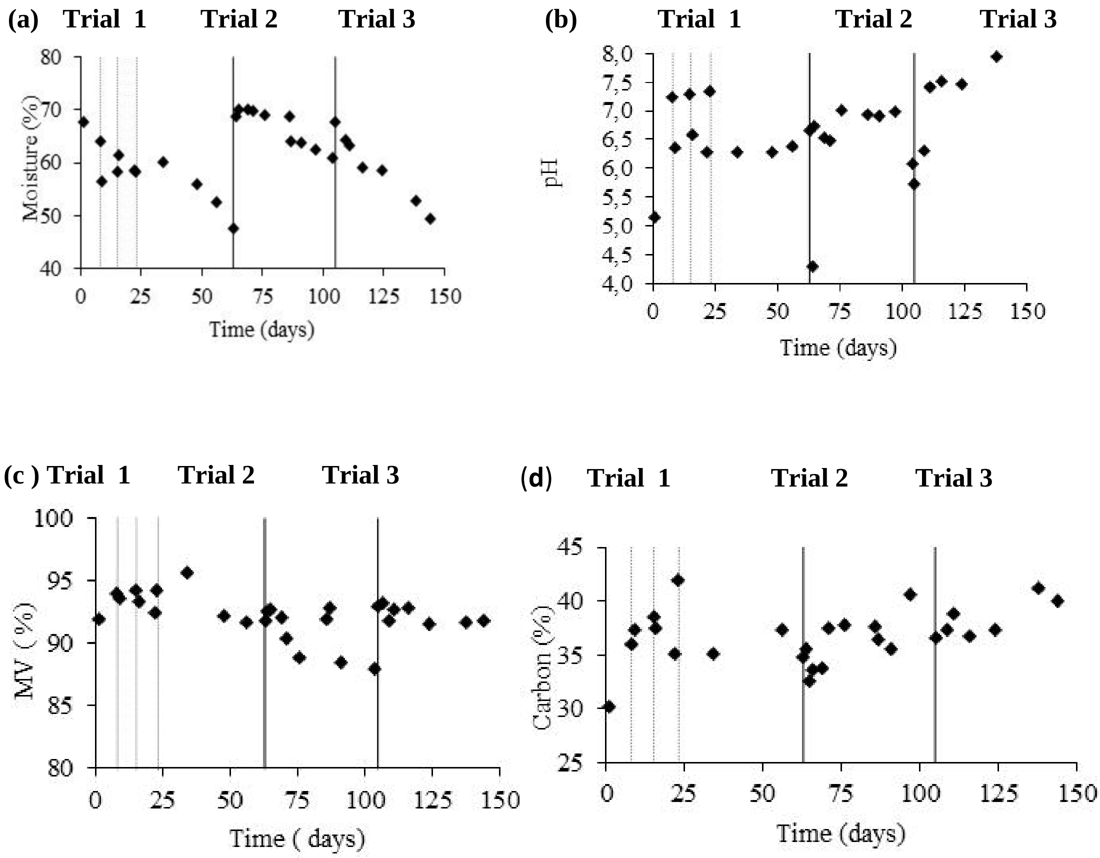


Fig. 3Physic chemical parameters in the trials.

At the end of the composting, it was observed 56 % of lost weight in the trial 1, 28 % in the trial 2 and 49 % in trial 3 (Figure 4).Small production compost (particle size < 0,42 mm) occurredin the range of 0,5 to 2,2 % of dry weight. The C and N ratio and pH is in accordance with Brazilians norms, the moisture wasslightly above, but nitrogen and total coliforms were out of standards. Therefore, the compost is not adequate for agriculture use, although the small production (Table 6)brings a beneficial mass reduction of waste.

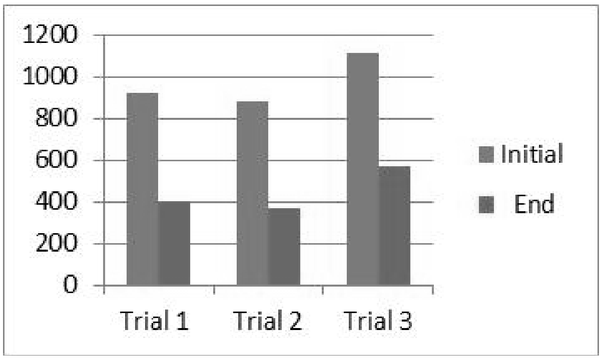


Fig. 4-Dry Weight at initial and in the end of trial

Table 6 Compost Characterization in the trials

Parameters	Trial1	Trial2	Trial3
Dryweigt	8.9	4.2	6.3
Moisture 65°C(%)	28.0	50.7	50.3
VS (%)	66.5	80.9	82.3
Carbon (%)	31.8	40.8	37.3
Nitrogen (%)	1.6	2.5	2.9
C:N ratio	19.9	16.4	13.1
pH ($CaCl_2$)	6.7	7.6	8.0
Total Coliforms (MPN/g)	7.6×10^2	2.9×10^3	3.8×10^3
E. coli (MPN/g)	4,1	1.9×10^3	2.5×10^2

Conclusions

In conclusion the stabilization of food waste is possible in a simple composter with waste and a bulking agent, in this case wood chips, but the compost qualityis not adequate for the agriculture use.The reuse of bulking agent improves the system efficiency for carbon reduction. Small-scale production of compost can be useful for places with limited space, but improvements are necessary to achieve thermophilic temperatures in order to ensure the reduction of pathogensmicroorganisms indicators.

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