JASEM ISSN 1119-8362

Full-text Available Online at www.ajol.info and www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. *March,* 2012

Vol. 16 (1) 5 - 10

Evaluation of Composting and the Quality of Compost from the Source Separated Municipal Solid Waste

[1*]DESSALEGN DADI; [2]HAMEED SULAIMAN; [3]SEYOUM LETA

[1]Department of Environmental Health Sciences and Technology, Public Health and Medical Sciences College, Jimma University, P.O.Box:378, Ethiopia
[2]College of Science, Sultan Qaboos University, P.O.Box 36, PC 123, Al-Khodh, Muscat, Sultanate of Oman.
[3]Addis Ababa University, Faculty of Sciences, Environmental Science Program, P.O.Box:1176, Addis Ababa.

ABSTRACT: The aerobic composting potential and quality of Source Separated Municipal Solid Waste (SSMSW) was studied using four different treatments for over 80 days. Four different types of treatments using different inoculums were used for the composting of source separated municipal solid waste. The phytotoxicity tests of the different types of compost samples were conducted on 3 different types of seeds and 3 of the compost samples were rated very mature and only one of them is rated mature compost. The compost quality (physicochemical, nutrient composition & heavy or trace metal concentration of the matured composts) of the studied compost samples for all the treatments indicated that composting of SSMSW with cow dung is the best of all the treatments. @JASEM

Key Words: Compost, MSW, Matured composts, phytotoxicity.

Inadequate municipal and industrial solid waste collection and disposal creates a range of environmental problems. For instance the report of Addis Ababa city health bureau, compiled from 15 health centers for 1991, indicated that two of the leading top-ten causes of morbidity in the city were acute upper respiratory diseases and infections of skin and subcutaneous tissues. This accounts for one-third of the total outpatients (Beyene Geleta, 1999). The high organic content in the MSW stream of developing countries is ideal for composting. For example, studies conducted on the composition of solid waste of Addis Ababa city reveals that 90% by volume and 50% by weight is organic decomposable waste (Addis Ababa Bureau of Health, 1997 as cited by Getaneh Gebre and Tesfaye Beyene, 2006). Hence, processing of this significant amount of resource into valuable compost enhances the practices of solid waste management of the city. Source separating the municipal solid waste before collection is usually an environmentally and technically better way to improve the quality of the final compost.

MATERIALS AND METHODS

For the purpose of this study, SSMSW at household level from the local residents living around the compost demonstration site managed by Addis Ababa- EPA was used. The residents were given two different colored buckets (green for compostable wastes and red for non compostable wastes) of the same size for source separation of wastes generated from their home. For more quality composting, the waste was again separated and chopped to increase the surface area, rate of decomposition and hence the quality. The inoculums cow dung & sewage sludge were collected from the local communities and biogas slurry (bio-sludge) was obtained from Addis Ababa University (AAU) biogas treatment. Variations in composting temp were measured using the digital thermometer. The pH of compost samples was measured by a pH meter by taking a sub-sample (5 gram) of air-dried ground compost and transferred into a bottle and 25ml of deionized water was added (i.e. compost water suspension at 1:5 ratio). The bottles were capped and shaken mechanically at 200 revolutions per minute for 15 minutes. For the determination of EC values of the compost samples**,** the compost samples were diluted with H_2O using a mass ratio of 5:1 (water: dry compost) and shaked mechanically for 20 minutes, measure EC in slurry or extract. For the determination of heavy metals the AAS (Atomic Absorption Spectrophophotometery) Buck scientific model 210 VGP flame atomic absorption spectrometer was used.

The Total N, Total P, Exchangeable K and organic matter, of the compost samples were determined using the Kjeltec System, Sodium Hydroxide fusion method, Ammonium Acetate Extraction Method and Walkley and Black method, respectively.

Phytotoxicity test of the different types of composts were conducted on three different types of seeds. These seeds were Maize (corn), peas and chicken

**E-mail:* hanhameco@gmail.com, desalegndadi@yahooo.com; E-mail: hameed@squ.edu.om

peas (locally named Shimbra) and have been used for the maturity test of the prepared compost types. Statistical Analysis of experimental results was performed using the SPSS and MINITAB packages Release 13.00 for windows statistical software package.

Experimental Set Up: Four different treatments each having 3 replicates with the total of 12 piles (heaps) were prepared with different composition of MSW, cow dung, bio-sludge and sewage sludge. That is treatment 1 (T1) is composted only from MSW and is acted as a control. While, treatment 2 (T2) was MSW with cow dung; treatment 3 (T3) was MSW with biosludge and treatment 4 (T4) was composted with the mixture of MSW, cow dung, sewage sludge and biosludge. The composts base area was $1m^2$ and 1m long ($1m^3$ in volume). The experimental set up is depicted in figure 1. The compost piles were turned and watered twice per week uniformly for all the treatments for the first two months and once per week later on. The piles were turned on less windy, relatively calm weather, damp days to reduce the dissipation of process odors (Edwards, 2003; Bidlingmaier, 1996).

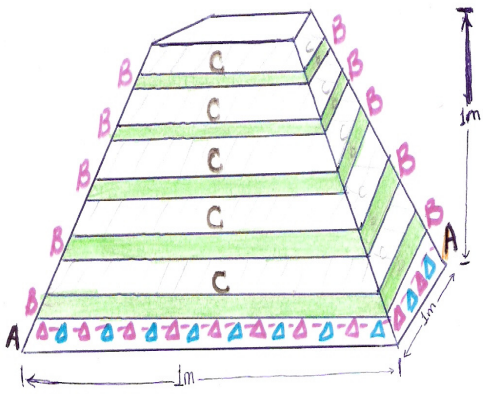

Fig.1 Diagrammatic representation of compost heap

The compost samples were taken from each pile on different stages of composting process from day 13 (D13) to 78th day (D78) from all sides of the pile and thoroughly mixed together to get a homogenous and representative sample of the entire pile and thus ground using a pestle and mortar to pass through a sieve to minimize sub-sample variability.

RESULTS AND DISCUSSION

At the maturity phase, the pH of all the composting treatments was found to be within 7.83 ± 0.01 -8.11 ± 0.05. The results are shown in Table 1. This result is in agreement with the compost quality standards for compost used in agriculture in Switzerland (pH < 8.2) and Great Britain (7.5-8.5). In addition, it is in the recommended range for the quality compost used by the countries such as Dutch, Belgium & Italy that is 6.5-8.5. However, it is in close proximity with the compost quality standard for compost used in agriculture in India (6.5- 7.5). Similar pH values on MSW composts were reported by Holmer (2002) within 5.5 - 8.5; Cooperband (2002) within 5.5 – 9.0; and Mona (2003 as cited by Herity, 2003) within 6.9-8.3 ranges. Hence the matured compost of this study is very promising, since no chemicals are required to balance the pH before applying to soils. Generally, the EC values increases slightly from the initial composting period to the final composting stages. This increase in EC might be due to the slight increase in Potassium ions (K^+) and other ions as decomposition proceeds. The increase in EC could be due to the release of mineral salts such as phosphates and ammonium ions through the decomposition of organic substances (Huang *et al*., 2004). Study by Anandavalli *et al*. (1998) on recycling of banana Pseudo stem as compost also show similar EC increment as the composting process proceeds.

The mean EC values of all the treatments of matured composts were found to be between 3.39 ± 0.04 -3.83 ± 0.02 ms/cm. This result is in agreement with the quality compost used by the countries such as Dutch, Belgium and Italy that is < 5 ms/cm. Similarly, this result is in the recommended range by Mona (2003 as cited by Herity, 2003) within 2-6ms/cm and Cooperband (2002) which is below 10ds/m. Generally, the soluble salt content of the matured composts will not harm most plants as explained by Mamo *et al.* (2002) who stated that most plants could not tolerate a soluble salt content greater than 4mmhos/cm.

Total Nitrogen: The Total N of matured composts for all the treatments was found to be in between 1.05 - 1.13 % dry weight. The results are shown in Table 2. This result is in agreement with the quality compost criteria, which is used by the counties such as Dutch, Belgium and Italy that is ≥ 0.7%. Similarly, the result is in conformity with recommendations for total N in compost by Barker (1997 as cited in Herity ,2003) that is 1-3% dry weight and Ontario ministry of the environment (2004) that recommended the typical minimum concentration (% dry weight) of Total N as 0.6. Similarly, the result is in agreement with compost quality standards for compost used in agriculture in Switzerland (> 1 %) and India (> 0.8

%). Besides, the result is in agreement with the recommendations of Barker (1997 as cited in Herity ,2003) who stated that to report compost as having fertilizing capabilities and for it to be used in agriculture the Total N content must be over 1% dry weight. Therefore, since the compost samples have Total N over 1%, they have fertilizing capability and can be used in agriculture and hence no supplemental N is needed.

Table 1: Changes in physico-Chemical parameters (mean values) during the different stages of composting

Parameter	Date of decomposition	Treatment 1	Treatment 2	Treatment 3	Treatment 4
		Mean Value	Mean Value	Mean Value	Mean Value
pH	D13	8.32 ± 0.01	8.34 ± 0.02	8.10 ± 0.05	8.17 ± 0.01
	D24	8.47 ± 0.06	8.19 ± 0.01	8.30 ± 0.01	8.28 ± 0.06
	D35	8.58 ± 0.03	8.32 ± 0.02	8.04 ± 0.07	8.11 ± 0.01
	D43	8.22 ± 0.01	8.24 ± 0.01	8.58 ± 0.04	8.93 ± 0.07
	D52	8.37 ± 0.01	8.33 ± 0.03	8.15 ± 0.02	8.34 ± 0.01
	D70	8.11 ± 0.02	8.05 ± 0.05	7.82 ± 0.03	7.96 ± 0.03
	D78	8.11 ± 0.05	8.05 ± 0.07	7.83 ± 0.01	8.02 ± 0.07
EC (mS/cm)	D13	2.78 ± 0.01	2.89 ± 0.07	3.71 ± 0.02	3.59 ± 0.05
	D24	3.71 ± 0.05	3.97 ± 0.04	3.64 ± 0.13	4.28 ± 0.01
	D35	3.73 ± 0.07	3.58 ± 0.01	3.50 ± 0.01	3.61 ± 0.05
	D43	3.40 ± 0.04	2.99 ± 0.05	3.23 ± 0.05	2.98 ± 0.04
	D52	3.24 ± 0.04	2.95 ± 0.02	3.28 ± 0.05	3.42 ± 0.01
	D70	3.52 ± 0.04	3.67 ± 0.05	3.27 ± 0.05	3.5 ± 0.04
	D78	3.82 ± 0.03	3.39 ± 0.04	3.43 ± 0.28	3.83 ± 0.02
TDS(g/L)	D13	1.27 ± 0.03	1.33 ± 0.00	1.68 ± 0.01	1.68 ± 0.01
	D24	1.71 ± 0.00	1.83 ± 0.01	1.78 ± 0.01	1.96 ± 0.02
	D35	1.69 ± 0.02	1.67 ± 0.00	1.64 ± 0.00	1.74 ± 0.04
	D43	1.50 ± 0.00	1.34 ± 0.00	1.46 ± 0.00	1.32 ± 0.00
	D52	1.46 ± 0.00	1.37 ± 0.02	1.51 ± 0.00	1.53 ± 0.00
	D70	1.60 ± 0.00	1.68 ± 0.00	1.46 ± 0.00	1.57 ± 0.00
	D78	1.65 ± 0.00	1.49 ± 0.00	1.47 ± 0.12	1.67 ± 0.07

Total Phosphorous: The Total P % content of the matured composts for all the treatments were found to be in between 0.45 – 0.51%. This result is in conformity with the recommendations of Ontario ministry of the environment (2004) that recommended the typical minimum conc. (percentage dry weight) of total P as 0.25. In addition, the result obtained was in agreement with the recommendations of Mona (2003 as cited in Herity, 2003) who recommended that the range of Total P to be 0.4-1.1%.

Exchangeable Potassium: The exchangeable K values increases gradually from the initial composting period to the final composting stages for all the treatments as shown in Table 2. Study by Anandavalli *et al*. (1998) on recycling of banana Pseudo stem as compost also showed Total K increment as the composting process proceeds.

*Organic Matter***:** Generally, the organic matter values decreases significantly from the initial composting period to the final composting stages for all the treatments as shown in Table 2. The reduction in organic matter with time is also reported earlier by Anandavalli *et al.* (1998), FFTC (2007) and Greenway and Song (2002).

*Carbon to Nitrogen Ratio (C/N)***:** The C/N ratio of the studied compost samples are in agreement with the compost quality standards used by the countries such as Dutch, Belgium and Italy that is less than 18 and the recommendations of Kuo *et al*.(2007) who stated that mature compost has a C/N ratio of approximately 10:1. Similarly, the result is within the range of the Ethiopian Federal EPA guidelines that recommended the C/N ratio of good quality compost to have a final C: N ratio of 29:1 or less (FEPA, 2004).

*Heavy (Trace) metal concentration of the matured composts***:** The overall treatments metal concentrations (Table 3) were within the acceptable limits of the proposed standards by the World Bank for MSW composts in developing countries (Hoornweg *et al.,* 2000).Therefore, these compost samples can be readily used for agricultural purposes.

Table 2: Changes in nutrient compositions during the different stages of composting

Parameter	Date of decomposition	Treatment 1	Treatment 2	Treatment 3	Treatment 4
TN (%)	D13	1.19	1.27	1.23	1.20
	D24	1.14	1.40	1.24	1.31
	D35	1.17	1.14	1.07	1.15
	D43	1.06	0.99	1.10	1.13
	D52	1.06	1.01	1.14	1.15
	D70	1.07	1.11	1.05	1.13
TP (%)	D13	0.66	0.44	0.51	0.40
	D24	0.53	0.50	0.46	0.50
	D35	0.45	0.45	0.40	0.47
	D43	0.33	0.25	0.47	0.50
	D52	0.34	0.35	0.53	0.32
	D70	0.50	0.51	0.45	0.45
EXC.K (meq/100g)	D13	37.69	39.49	32.57	32.35
	D24	40.04	42.08	39.15	39.34
	D35	23.41	28.43	25.82	24.02
	D43	39.97	40.32	36.45	38.81
	D52	38.20	38.12	39.40	40.92
	D70	44.37	43.93	36.88	39.64
OM (%)	D13	28.07	34.46	35.64	26.73
	D24	20.00	19.83	24.88	24.20
	D35	22.02	22.02	17.46	20.84
	D43	19.16	17.65	19.16	19.50
	D52	16.30	17.31	17.65	19.33
	D70	16.81	22.02	19.50	19.50
C/N	D13	13.68	15.74	16.80	12.91
	D24	10.18	8.21	11.64	10.72
	D35	10.91	11.20	9.48	10.51
	D43	10.48	10.34	10.10	10.00
	D52	8.91	9.94	8.98	9.75
	D70	9.11	11.50	10.77	10.00

Table 3: Heavy (Trace) metal concentration of the matured composts (mg/kg of dry weight)

	Treatments			
Trace Metals	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Cadmium	0.3995 ± 0.0696^{b}	0.989 ± 0.0317^{a}	0.34176 ± 0.0169^{b}	0.4604 ± 0.0459^{b}
Chromium	10.095 ± 5.0085^{c}	19.675 ± 2.7048^{b}	34.5695 ± 8.4503^{a}	13.188 ± 3.4479^{c}
Cobalt	17.075 ± 0.3377^{a}	13.9 ± 0.2471^{b}	16.5153 ± 1.1769^{a}	16.416 ± 0.5773^{a}
Copper	32.536 ± 0.4295^{b}	29.62 ± 1.0681^{c}	41.845 ± 0.4705^{a}	33.852 ± 2.1408^{b}
Lead	234.886 ± 10.1094^{a}	42.4619 ± 7.5639^{b}	48.724 ± 6.6695^{b}	38.1567 ± 3.5551^{b}
Nickel	31.656 ± 3.0068^{a}	23.16 ± 3.8058^{b}	25.7125 ± 2.8691^{b}	19.995 ± 1.8850^{bc}
Zinc	176.71 ± 29.0996^{a}	159.978 ± 25.6355^{a}	185.454 ± 29.7555^{a}	183.956 ± 28.4657^{a}

Key: Values with the same letters are not statistically significant

Plant phytotoxicity test: As shown below in Table 4, compost samples of T1, T2 and T3 are rated very mature since the seeds germination and growth values are > 90 % indicating that the matured compost is free of plant phytotoxic materials that could inhibit the seeds germination and growth. This observation is in conformity with the recommendations of California Environmental protection Agency (2002); Brinton (2000) and Herity (2003). Nevertheless, T4 is rated mature compost since the seeds germination and growth value is > 80% according to the recommendations of California Environmental protection Agency (2002) and Brinton (2000).

Table 4: Plant phytotoxicity test for the different treatments

Treatment	Plant	Plant Phytotoxicity test (%)	Overall Plant Phytotoxicity test (%)
T1	Chick Pea	87.5	91.67
	Peas	87.5	
	Corn (Maize)	100	
T2	Chick Pea	100	100
	Peas	100	
	Corn (Maize)	100	
T3	Chick Pea	87.5	91.67
	Peas	100	
	Corn (Maize)	87.5	
T4	Chick Pea	75	83.34
	Peas	87.5	
	Corn (Maize)	87.5	

Conclusion:

Treatment 2 (MSW with cow dung) is the best of all the treatments because of its maximum contents of Total Phosphorous, organic matter ,organic carbon and C/N ratios at the maturity level (at the end of the composting process).The concentration of heavy metals varies with different treatments and was inconsistent. Generally, the trace metals concentration was within the acceptable limits for the proposed standards MSW compost in developing countries. Thus, it is recommended that the application of source separated MSW composting with different inoculums in the cities of developing countries can be considered as a technically as well as economically viable option for SWM.

Acknowledgement: We would like to express our heartfelt and deep gratitude to staff members of AAU particularly, Applied Microbiology, Chemistry department (especially Inorganic Chemistry & Chemical Instrumentation), and Geophysics laboratory technicians for their kind cooperation and permission to use their laboratory freely; and Addis Ababa EPA for allowing us to use the compost demonstration site & water supply freely throughout the composting process.

REFERENCES

Anandavalli, D.; Ramaswami, P. and Hameed, S.(1998).Recycling of Banana Pseudostem as compost. J.Ecotoxicol.Environ.monit.80:191-194.

Beyene Geleta (1999). Managing solid waste in Addis Ababa .25th WEDC conference: Integrated development for water supply and sanitation. PP.323-325. Addis Ababa, Ethiopia.

Bidlingmaier, W. (1996). Odor Emissions from Composting Plants, In Bertoldi,M.;Sequi,P.; Lemmes,B.; and Papi,T.(Eds), The Science of Composting, European Commission International Symposium. Blackie Academic and professional, Glasgow.

Brinton, W.(2000). Compost Quality Standards and Guidelines: Compost quality in America. Woods end Research Laboratory incorporated, New York.

California Environmental Protection Agency (2002). Compost Maturity and Nitrogen release characteristics in central coast Vegetable Production. Watsonville, California

Cooperband, L. (2002).The Art and Science of Composting: A resource for farmers and Compost producers. Center for Integrated agricultural systems; University of Wisconsin – Madison

Edwards, S.(2003). Natural Fertilizer: Based on the Tigirinya booklet by Arefaine Asmelash Institute for sustainable development. Addis Ababa, Ethiopia.

FEPA (Federal Environmental Protection Authority of Ethiopia). (2004). Guidelines on composting. Addis Ababa, Ethiopia.

FFTC (Food and Fertilizer Technology Center). (2007).What happens during Composting? Taipei, Taiwan.

Getaneh Gebre and Tesfaye Beyene (2006). A case study on household waste sorting and

composting. (Unpublished material).Addis Ababa.

Greenway, G. and Song, Q. (2002).Heavy metal speciation in the composting process. J.Environ.monit:4:300-305.

Herity, L (2003).A study of the quality of waste Derived compost in Ireland. M. Sc Thesis, Queens University of Belfast

Holmer,R. (2002). Basic Principles for composting of Biodegradable household wastes. Cagayan De Oro City, Philippines.(http://puvep.xu.edu.ph/publications/basic- composting.pdf)

Hoornweg,D.,Thomas,L. and Otten,L.(2000).Composting and its applicability in developing Countries-Working Paper series 8-published for the urban development division-The world bank, Washington DC.

Huang, G., Wong, J. Wu, Q. and Nagar,B. (2004). Effect of C/N on Composting of Pig Manure with Sawdust. Waste management 24: 805-813

Kuo, S., Ortiz-escobar, M., Hue, N. and Hummel, R. (2007). Composting and compost Utilization for Agronomic and Container Crops. Washington State University. (http://www.ctahr.hawaii.edu/huen/composting_compost_util.pdf)

Mamo, M., Halbach,T. and Rosen,C.(2002).Utilization of MSW compost for crop Production. University of Minnesota. (http://www.extension.umn.edu/distribution/natural resources/DD 7083.htm/)

Ontario Ministry of the Environment. (2004).Interim Guidelines for the production and use of aerobic compost in Ontario. Ontario.