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Annex II

Analysis of Municipal Solid Waste Compost on Compliance with Sri Lanka Quality Standards (SLS 1246:2003)

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ABSTRACT

Compost is made from Municipal Solid Waste (MSW) containing discarded household, market and industrial waste materials such as paper, food scrapes, wood, grass clippings, metal, plastics, batteries, electronic items, clothing, packaging materials etc. Therefore, composition of MSW compost is slightly different from compost made from pure agricultural wastes. Composting of MSW is carried out in 120 composting sites, located Island wide under Pilisaru project. Production in these sites are available for agricultural applications. Even though Sri Lanka Standards Institution has published quality standards for MSW compost under the schedule number SLS 1246:2003, quality of MSW compost produced in Sri Lanka are not available in literature. Therefore, this study was carried out with the objective of understanding the quality of MSW compost made in different composting sites representing all provinces of the Island. Samples from 11 compost sites were obtained and all laboratory tests were performed according to the standards published by Sri Lanka Standards Institution. Analytical data were compared with SLSI standards for MSW compost. Data were analyzed and compost site grading index was formulated. No site was found with 100% compliance with SLSI standards. Among 11 compost sites, Kurunegala site had the highest compliance (78.60%) while Kaduwela had the lowest compliance (52.45%) with SLSI standards. Therefore, it is suggested that suitable measures should be adopted to uplift the quality of MSW compost produced in Sri Lanka.

KEYWORDS: Compliance, Compost, Municipal Solid Waste, Quality, Sri Lankan Standards

INTRODUCTION

Municipal Solid Waste (MSW) compost is the biodegradable part of MSW converted into manure through decomposition by microbes (Anon, 2013). Municipal Solid Waste consists of waste materials of day - to - day items which originate from domestic and industrial sources such as product packaging, food scrapes, papers, electronic appliances and batteries (USEPA, 2016). As in many other developing countries, MSW management has been identified as one of the main environmental issues in Sri Lanka. It has given rise to many environmental problems in Sri Lanka (Gunaruwan and Gunasekara, 2016).

Total collection of MSW by local authorities in Sri Lanka is around 3740 tons per day. Total waste generation is around 6400 tons per day and 60% of that is collected from the Western province (Anon, 2017).

The Sri Lankan government has proposed various programs to reduce the accumulation of MSW in the country to a considerable extent. Composting, Biogas production and 3R concept (reduce, recycle and reuse) are some of the strategies which has been planned by the government (Bandara, 2010). To prepare compost from MSW, there are about 120 compost sites under the Pilisaru project implemented by Central Environment Authority (CEA) covering all 25 districts in Sri Lanka (Anon, 2008).

United Kingdom (UK), United States of America, Canada and Germany like developed countries already maintain standards to assess the quality of MSW compost. As the responsible government body, Sri Lanka Standards Institution (SLSI) has introduced the Sri Lanka Standards for MSW compost in 2003 and documented as SLS 1246:2003.

There are three main requirements in this specification; namely physical, chemical and biological. Colour, odour, moisture content, particle size and sand contents are physical requirements while pH, organic C, N, P, K, Mg, Ca contents, C: N ratio, Cr, Pb, Ni, Cu, Zn and Cd contents are chemical requirements. Absence of *Salmonella* and *faecal coliform* are biological requirements.

Even though standards for MSW is published (SLS 1246:2003), values of parameters of MSW compost made in different municipalities have not been published yet and

therefore, quality of MSW compost in Sri Lanka is not understood yet.

Therefore, this study was carried out to assess the physical, chemical and biological parameters of MSW compost as given in the SLSI standards to understand the quality of compost made in composting sites of different municipalities under Pilisaru project representing all provinces of the Island.

MATERIALS AND METHODS

Location

The study was carried out in the Soil Science laboratory of the Regional Agriculture Research and Development Center, Makandura and the laboratory of the Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), from May to September 2017.

Sample Collection

Municipal Solid Waste compost samples were collected using selective sampling technique from 11 compost production sites namely Attanagalla, Badulla, Balangoda, Chawakachcheri, Kaduwela, Kattankudy, Kuliyapitiya, Kurunegala, Medirigiriya, Nawalapitiya and Rajgama representing all nine provinces of Sri Lanka. Total of forty four samples were used to analyze for all specified parameters with four replicates from each compost production site. For all laboratory testing, procedures laid down in SLSI standards manual (SLS 1246:2003) was followed.

Determination of Physical Properties

Sand Content

Dried compost samples of 100 g were transferred into 1000 mL measuring cylinders and water was added. Measuring cylinder was shaken and left to settle for about ten minutes. Water and floating particles were decanted by leaving the sand at the bottom. Residue was washed out thoroughly with water. Sand was transferred into a Petri dish and dried in an oven at 103 ℃ for one hour (SLS 1246:2003).

Particle Size

Dried compost sample of 100 g was transferred to a sieve of 4 mm aperture size and shaken for 5 minutes. Remaining residue on the sieve was weighed.

Moisture Content

Moisture content was determined according to the procedure described in SLS 645: part 2 (2009).

Colour and Odour

Colour of compost samples were determined using Munsell colour chart and odour was determined by sensory evaluation.

Determination of Chemical Properties

N, P, K, Ca and Mg Contents

These were determined by the methods described in SLS 645 part no.1, 5, 4 and 6 respectively.

Heavy Metal Content (Cd, Cr, Cu, Pb, Ni, Zn)

These heavy metals were determined by using AOAC (975.03) digestion method and Atomic Absorption Spectrometer detection method (Helrich, 1990).

pH and Electrical Conductivity (EC)

pH and EC were determined using 1:5 water solution method described in ISO 10390 (2007).

Organic Carbon Content (OC)

OC was determined by Walkey Black method described in SLS 1246:2003.

Determination of Biological Properties

Faecal coliform and *Salmonella* were tested using the methods described in SLS 516 part 3 and part 5 respectively (SLS 1246:2003).

Statistical Analysis

Descriptive statistical analysis was done to obtain mean, standard deviation and standard error for all 11 compost sites for each physical and chemical parameter. One sample t- test was performed to compare the analyzed data with standard values published by SLSI. Analysis of Variance carried out to compare each compost site by using SAS statistical software (Version 9.4).

RESULTS AND DISCUSSION

Comparison of Chemical Properties with SLSI Standards

Comparison of chemical properties with SLSI standards are given in Table 1. SLSI standards for pH range lies between 6.5 and 7.5. As no significant difference was found for pH values of tested sites, it can be concluded that MSW compost produced in all tested sites were in compliance with SLSI standards. It was found that N content of MSW compost in Badulla, Balangoda, Kuliyapitiya, Kurunegala, Nawalapitiya and Rajgama sites were in compliance with the SLSI standards as those sites had no significant difference with the standards. All sites were in compliance with

SLSI standards for P content except Kuliyapitiya. For K content, Badulla, Chawakachcheri, Kattankudy, Kuliyapitiya, Kurunegala, Medirigiriya and Nawalapitiya compliance with SLSI standards. Carbon to Nitrogen ratio of compost in Attanagalla, Chawakachcheri and Kattankudy sites (10:1-25:1) were in compliance with SLSI standards. For Ca content, Badulla, Chawakachcheri, Kurunegala, Medirigiriya and Nawalapitiya sites (>0.7) were found to be in compliance with SLSI standards. Mg content of all sites were significantly lower than the SLSI standards.

Comparison of Physical Properties with SLSI Standards

Comparison of physical properties with SLSI standards are shown in Table 1. Moisture content of Badulla, Balangoda, Katttankudy, Medirigiriya, Nawalapitiya and Rajgama sites (<25%) were in compliance with SLSI standards. All sites were in compliance with standards for particle size except sites Chawakachcheri and Medirigiriya. Those two sites had exceeded the maximum limit of 2% for particle size. Only Balangoda and Rajgama sites were in compliance with SLSI standards for sand content (<10%).

Comparison of Heavy Metals with SLSI Standards

SLSI standards for Cd, Pb and Cr content are <10, <250, and <1000 ppm respectively. According to the data recorded, all compost sites were in compliance with the SLSI standards with regard to Cd, Pb and Cr. Further, it was found that Cu, Ni, and Zn content of compost samples taken from Balangoda, Rajgama and Kaduwela sites were not in the permissible level (Cu <400 ppm; Ni<100 ppm; Zn<1000ppm) (Table2).

Comparison of Biological Properties with SLSI Standards.

It was found that MSW compost sample from site Badulla was not in compliance with the SLSI standards as *Salmonella* was present in the sample. Further, MSW compost samples taken from sites Attanagalla, Badulla, and Kaduwela were not in compliance with SLSI standards due to presence of *faecal coliform* (Table 2).

This study revealed that some physical and chemical parameters vary widely among sites. It may be largely due to the properties and types of the raw materials received to produce MSW compost in Pilisaru project. Operational variances and different climatic conditions of production sites may also be reasons for quality differences. Tang *et al.* (2003), in his study indicated that most of the parameters including moisture, organic C content and C: N ratio have considerable amount of variation in compost made from MSW due to the above reasons.

Gunarathne and Gunathilaka (2016), reported that heavy metals content of MSW compost were in the acceptable level for Cu, Zn, Cr, Cd, Ni and Pb as recommended by SLSI. Even though some sampling sites are different, the present study revealed that Zn, Ni, and Cu content were not in the permissible level in some compost sites. However, Cd, Cr and Pb content of all sites were in compliance with SLSI standards. Heavy metal containing batteries, electronic appliances and some industrial machinery items mixed with MSW are the sources for heavy metals. Usage of proper methods for the disposal of such items are important to control the heavy metal contents in MSW as implemented in developed countries. It was found that most international standards for MSW compost are more advance than ours and therefore Sri Lanka too should try to achieve those standards for healthy life.

Considering the comparisons of all parameters with SLSI standards, it is possible to formulate the Compost Site Ranking Index (CSRI), ranking each site according to their compliance for each parameters.

$$CSRI=\sum_{i=1}^{n}\frac{wipi}{\sum wi} \quad \text{..... (1)}$$

Where,

No.	Compost site	Percentage of site, compliance with the standards (%)
1	Kurunegala	78.60
2	Chawakachcheri	73.85
3	Kattankudy	73.85
4	Kuliyapitiya	73.85
5	Badulla	73.69
6	Rajgama	69.09
7	Medirigiriya	66.71
8	Nawalapitiya	66.71
9	Attanagalla	64.34
10	Balangoda	61.97
11	Kaduwela	52.45

CSRI= Compost Site Ranking Index

w_i = i^{th} parameter weight

p_i = i^{th} parameter value

n = number of parameters

According to the above equation compost sites were graded (Table 3).

Table 3. Grading of compost sites on compliance with SLSI standards

Suggestions to upgrade the Quality of MSW Compost

According to the analyzed data, it was found that only some parameters were in compliance with the SLSI standards. Awareness on the quality of each and every compost site administration is necessary for them to implement suitable measures to upgrade the quality of their compost.

Table 1. Comparison of chemical and physical parameters with SLSI standards

CS	pH	N	P_2O_5	K_2O	OC	C/N	CaO	MgO	MS	PS	S
Attanagalla	7.39[a]	0.71[b]	1.31[a]	0.52[b]	7.09[b]	10.12[a]	0.25[b]	0.17[b]	81.02[a]	2.12[b]	39.96[a]
Badulla	7.67[a]	1.37[a]	0.96[a]	1.58[a]	4.78[b]	3.57[b]	1.09[a]	0.31[b]	26.25[b]	0.99[b]	34.29[a]
Balangoda	6.91[a]	1.53[a]	1.25[a]	0.21[b]	7.31[b]	4.80[b]	0.14[b]	0.15[b]	17.46[b]	1.82[b]	9.45[b]
Chawakachcheri	7.82[a]	0.73[b]	1.32[a]	1.50[a]	8.49[b]	12.04[a]	1.04[a]	0.42[b]	51.59[a]	12.12[a]	30.28[a]
Kaduwela	7.57[a]	0.69[b]	1.61[a]	0.73[b]	5.89[b]	8.78[b]	0.24[b]	0.22[b]	46.24[a]	0.99[b]	50.35[a]
Kattankudy	7.64[a]	0.63[b]	1.08[a]	1.20[a]	7.31[b]	11.57[a]	0.32[b]	0.27[b]	8.36[b]	0.75[b]	48.34[a]
Kuliyapitiya	7.66[a]	1.37[a]	0.06[b]	1.91[a]	10.96[b]	8.12[b]	1.11[a]	0.35[b]	30.92[a]	0.10[b]	20.56[a]
Kurunegala	7.81[a]	1.37[a]	1.86[a]	2.85[a]	0.32[b]	7.68[b]	1.10[a]	0.41[b]	48.08[a]	1.49[b]	33.89[a]
Medirigiriya	7.78[a]	0.94[b]	0.90[a]	2.48[a]	8.09[b]	8.79[b]	1.14[a]	0.39[b]	19.88[b]	4.88[a]	27.83[a]
Nawalapitiya	7.61[a]	1.40[a]	1.99[a]	1.37[a]	12.24[b]	9.03[b]	1.13[a]	0.29[b]	22.12[b]	0.19[b]	29.24[a]
Rajgama	7.03[a]	1.36[a]	1.37[a]	0.06[b]	8.62[b]	6.36[b]	0.19[b]	0.16[b]	18.57[b]	1.33[b]	9.27[b]
SLSIV	6.5-8.5[a]	>1.0[a]	>0.5[a]	>1.0[a]	>20[a]	>10-25[a]	>0.7[a]	>0.5[a]	<25[b]	<2[b]	<10[b]

Means denoted by the same letters in a column represent non-significant differences at 0.05 levels; SLSIV- Standard Value, CS- Compost Site, N- Nitrogen percentage by mass, P_2O_5- Phosphorous percentage by mass, K_2O- Pottasium percentage by mass, OC- Organic Carbon content, C/N– Carbon to Nitrogen ratio, CaO- Ca percentage by mass, MgO- Magnesium percentage by mass, MS- Moisture content dry weight basis, PS- Particle size, S- Sand content

Table 2. Comparison of heavy metals and biological properties with SLSI standards

Compost Site	Cu (ppm)	Cr (ppm)	Cd (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)	*Salmonella*	FC
Attanagalla	230.70[b]	146.41[a]	5.99[a]	74.99[b]	155.02[a]	809.63[b]	Free	Yes
Badulla	13.07[b]	58.88[a]	0.04[a]	73.78[b]	7.99[a]	858.71[b]	Yes	Yes
Balangoda	458.36[a]	55.83[a]	7.56[a]	165.22[a]	113.53[a]	2210.39[a]	Free	Free
Chawakachcheri	29.93[b]	77.04[a]	0.03[a]	52.49[b]	2.91[a]	367.71[b]	Free	Free
Kaduwela	277.49[b]	16.92[a]	6.73[a]	116.92[a]	43.91[a]	454.00[b]	Free	Yes
Kattankudy	117.79[b]	16.04[a]	6.20[a]	113.97[a]	6.54[a]	406.12[b]	Free	Free
Kuliyapitiya	92.39[b]	79.26[a]	0.03[a]	86.51[b]	19.63[a]	627.43[b]	Free	Free
Kurunegala	68.44[b]	7887[a]	0.03[a]	32.9[b]	5.18[a]	743.93[b]	Free	Free
Medirigiriya	130.00[b]	75.37[a]	0.01[a]	44.46[b]	11.34[a]	1186.79[a]	Free	Free
Nawalapitiya	5.56[b]	169.83[a]	0.04[a]	102.68[a]	10.40[a]	1463.87[a]	Free	Free
Rajgama	494.81[a]	47.41[a]	5.79[a]	172.30[a]	88.87[a]	454.58[b]	Free	Free
SLSIV	<400[b]	<1000[a]	<10[a]	<100[b]	<250[a]	<1000[b]	Free	Free

Means denoted by the same letters in a column represent non-significant differences at 0.05 levels: SLSIV - Standard Value, FC- faecal coliform

All sites had the problem of lesser organic carbon content. This could be achieved by extending the decaying period or else intensifying the composting process by better compost management practices. To increase the Nitrogen in MSW compost, either plant or animal originated waste or treated faecal matter can be added as raw materials. By adding Eppawala Rock Phosphate, Phosphorous content can be increased. Public awareness and effective waste segregation procedure coupled with strict rules and regulations will help to reduce the heavy metal content of MSW. Frequent mixing, maintenance of proper moisture and aeration is important to avoid the development of unpleasant odour in MSW compost and faster decomposition. Recommended level of particle size can be achieved using standard (4 mm aperture size) sieving procedures. Results revealed that sand content of compost produced from all sites except Balangoda and Rajgama were very high. Therefore, suitable steps should be taken to avoid collection of sand into MSW materials as much as possible.

CONCLUSIONS

Results revealed that compost made in all 11 compost sites under study has complied only with some parameters of SLSI standards indicating that MSW compost made in these sites are not up to the Sri Lankan Standards. It was concluded that Kurunegala compost site has produced the best quality MSW compost (with 78% compliance) among all sites studied while Kaduwela had the lowest quality compost (with 52% compliance). Municipal Solid Waste compost produced by other sites have different compliance rates ranging from 61% to 73%.

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