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Research Note

Standardization of Sampling Method for Physical Characterization of Municipal Solid Waste

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Abstract: The physical characterization of the municipal solid waste (MSW) was carried out by hand sorting and the individual components were identified as food wastes, paper, cardboard, plastics, glass, metals, rags, rubber, leather, plant residues, wood wastes, miscellaneous organics, construction wastes, ash and dirt. The procedure for standardization of the minimum sampling size of the MSW was carried out by the reducing square method. Only the 6^{th} level of gradation, i.e., approximately 40.625 kg of MSW, contained all the representative components. Based on the mean deviation percentage of all the physical components between two squares, minimum acceptable sample size was standardized as 81.25 kg of well mixed municipal solid waste for physical characterization.

Key words: Sampling procedure, physical characterization, reducing square method, waste management.

Introduction

Solid waste production is an unavoidable, ever going but properly manageable process and it is directly proportional to the population growth. India generates about 210 million tons of municipal solid waste each day. The quantum of wastes produced increases at a rate of 1.5 per cent per year (Abbasi and Ramasamy, 2001). Solid waste contains a highly heterogeneous mass of unwanted materials, arising from human and animal activities, which complicates the solid waste management system.

The proper operation of a solid waste management system depends upon the composition of the solid waste. The quantity and quality of municipal solid waste depends upon various factors such as time of the year, geographical location and the habits of the contributing population (Ehlers and Steel, 1965). The quantity of solid waste generated in urban areas ranges from 0.3 to 0.5 kg/head/day, depending upon the habits of the people (Ahsan, 1999). Identification of the composition of municipal solid waste is carried out by quartering method (American Society of Testing and Materials, 1992; Peavy et al., 1985) as well as randomized sampling method.

The determination of the sample size is important for physical characterization of municipal solid waste. For physical characterization, some workers followed randomized sampling technique (Jeenger and Mathur, 2002; Daniel and Paul, 2003; Kaseva and Gupta, 1996) and have used 10 to 10,000 kg of wastes as samples to observe all the components of the municipal solid wastes. If the sample size is too small it cannot hold all the components of the municipal solid waste and if it is too large it will need more time and energy for segregation. Hence the proper sample size will have to be identified.

The physical components of municipal solid waste from different types of area i.e., domestic, commercial and mixed area, can be obtained from the standardization of proper sampling size through reducing square method. Hence a standard sampling technique for municipal solid waste should be worked out for each town and so also a reducing square method, which will give a solution to

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the problem for effective municipal solid waste management.

Methods

Physical characterization of municipal solid waste components, sampling (January 2002 to December 2004) in different types of area such as domestic, commercial and mixed area were carried out according to the method of Tchobanoglous et al. (1977). To assess the individual components present within the mass of the heterogeneous mixture of the municipal solid waste, a truck full of municipal solid waste was collected from each sanitary division (1 to 15) of Dindigul town, Tamil Nadu, India and transported to a corner of the dumping yard where the waste was segregated into different components by hand sorting.

The reducing square method was a modified sampling method of Peavy et al. (1985). To standardize the sampling procedure, a truck full of municipal solid waste was thoroughly mixed and spread to uniform height in a square. The waste square was divided into four equal triangular parts from which only two opposite triangles were removed, segregated manually and weighed to find out the components present in the municipal solid waste. After weighing, all the components were again mixed thoroughly and spread to uniform height in a smaller square and divided into four equal triangular parts. The composition of the municipal solid waste in the two opposite triangles was removed and segregated manually and weighed to find out the components. This reducing square method was repeated till the smallest sample size was obtained to contain all the representative components of the municipal solid waste.

Sampling of municipal solid waste was carried out three times in each of the fifteen sanitary divisions (n=45). From the mean deviation of results, the sampling error and minimum acceptable sampling size were calculated.

Results and Discussion

The results of the reducing square method revealed the minimum required sample size to obtain all the thirteen types of components of the municipal solid waste of Dindigul town and are given in Table 1. As indicated in the table, 1300.00 kg of municipal solid waste subjected to the sub-sampling procedure in the first square, only upto the sixth level of gradation, i.e., approximately 40.625 kg of the municipal solid waste, was found to contain all the representative components. However, due to variations in the weight of various representative components, sub-sampling upto the fifth level was found suitable for standardizing the sampling procedure, i.e., 81.250 kg of solid waste.

Standardization of sampling error of physical characterization of municipal solid waste using sub-sampling technique through mean deviation percentage is shown in Figure 1, which revealed that the highest deviation was observed between 81.250 and 40.625 kg, i.e. squares 5 and 6 for all the components. Square 6

Table 1: Physical configuration of the municipal solid waste of Dindigul town prepared following sub-sampling method (per cent)

Various components present in municipal solid waste	*Square 1**	*Square 2**	*Square 3**	*Square 4**	*Square 5**	*Square 6**
Food wastes	48.54	47.66	49.86	46.72	45.15	42.14
Paper	5.29	5.09	5.70	5.58	5.85	6.60
Cardboard	3.01	2.92	2.87	2.98	3.33	1.91
Plastics	6.07	5.87	5.79	6.27	6.47	4.83
Glass	0.56	0.58	0.55	0.53	0.52	0.47
Metals	0.54	0.52	0.50	0.57	0.49	0.43
Rags	4.91	5.13	4.55	5.42	4.24	3.12
Rubber	0.62	0.59	0.68	0.57	0.70	0.51
Leather	0.39	0.38	0.42	0.37	0.43	0.30
Plant residues	20.04	21.23	18.63	21.15	22.55	29.90
Wood wastes	2.00	1.92	1.98	1.86	2.20	1.51
Miscellaneous organics	4.32	4.23	4.46	3.98	4.68	5.48
Construction wastes, ash and dirt	3.71	3.88	4.01	4.00	3.39	2.80

* The quantity of municipal solid waste present in squares 1 to 6 are 1300.00, 650.00, 325.00, 162.50, 81.250 and 40.625 kg respectively

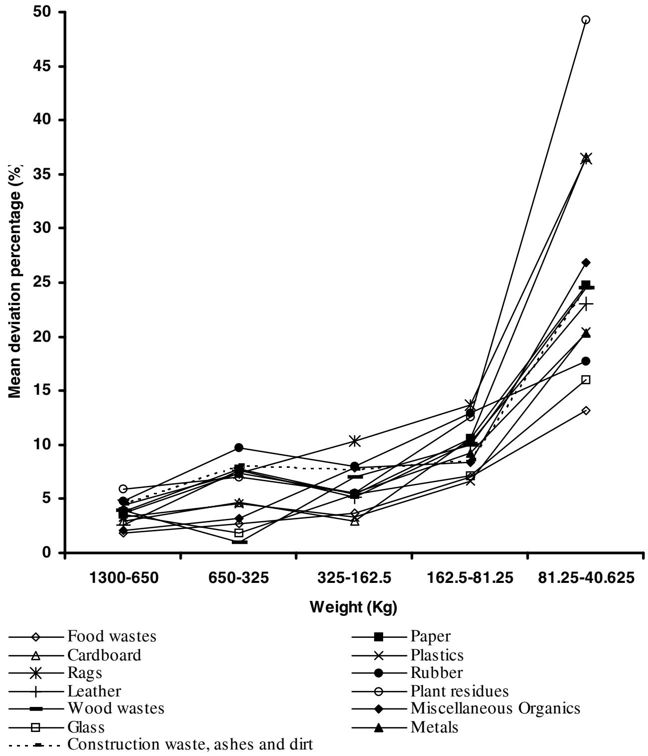

Figure 1: Standardization of sampling error through mean deviation percentage of physical characterization of municipal solid waste using sub-sampling technique.

showed the maximum deviation of 49.20 per cent for plant residues and the minimum deviation of 13.19 per cent for food waste and all other components showed a deviation between 16.07 and 36.54 per cent.

Studies on municipal solid waste management have been carried out by many workers in various places in India (Shekdar, 1989; Gupta et al., 1998; Daniel and Paul, 2004) and in other countries: Bangkok (Muttamara et al., 1996), China (Wei et al., 1997), Nigeria (Agunwamba et al., 1998), Thailand (Danteravanich and Siriwong, 1998), USA (Glen, 1999), Mexico (Buenrostro and Gerardo, 2001), Kuwait (Alhumoud and Al-Mumin, 2006) and Kenya (Henry et al., 2006). But, so far, in-depth work has not been carried out to standardize the procedure for sampling of municipal solid waste for physical characterization. However, the components of the municipal solid waste were identified by several workers (Kaseva and Gupta, 1996; Tchobanoglous et al., 1977; Ladhar, 2000).

The reducing square method followed in the present study is the first attempt to standardize the sample size in India for the observation of various components of the municipal solid waste. The per cent availability of the same components in the subsequent smaller squares varied depending on the bulk density of the total waste in the square. In all the squares observed i.e., 1 to 6, the food wastes and the plant residues were high indicating the presence of wastes from hotels, markets and houses. At the seventh square, some components of municipal solid waste were absent, which indicated that the sixth square was minimum suitable for the sampling. However, the standardization of the sampling error through mean deviation percentage of the physical characterization of municipal solid waste indicated 13.19 to 49.20 per cent mean deviation for 42.625 kg of wastes. Sfeir *et al.* (1999) suggested that 90 kg in each sample would have little statistical advantage. Based on the work of Klee and Carruth (1970) 50 samples of 90 kg sample sizes are required for acceptable precision. But in this study 45 samples of 81.25 kg of well mixed waste, which will contain all the 13 components, is recommended as the minimum acceptable sample size for the physical characterization study. This sample size can be adopted for studying the waste characterization in other Class I towns also, provided the wastes are thoroughly mixed before sampling.

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