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Seasonal variation in composition and characteristics of indian municipal solid waste –A case study

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Abstract
In developing countries like India, rapid urbanization and uncontrolled population growth have lead to the socio-environmental problem of ill-managed municipal solid waste. Evaluating the characteristics of municipal solid waste is an important aspect of MSWM because the selection of effective management strategies depends on the types and variation in the characteristics of the waste to be managed. The focus of the present paper is to determine the variation in composition as well as characteristics of municipal solid waste for Indian conditions. A case study is presented for Raipur city to determine the seasonal variation in waste characteristics. The seasonal variation in characteristics of MSW was found to be in a wide range of 4-125 %, so for comprehensive management of this MSW, a proper combination of recycling and recovery, composting, energy generation and dumping on land should be adopted.

Keywords: Muncipal solid waste, seasonal variation, characterization

INTRODUCTION

Municipal solid waste (MSW) generated by the community differs in quality as well as in quantity depending on several parameters like- habit of the people, living standard, location, climatic conditions etc. In India the variation in the parameters is very wide and thus the quality as well as quantity estimation for a city or state can not be simply extended for other locations to formulate an effective MSW management strategy. The estimation for the same city may also differ at different seasons of the year as well as months. Management of MSW constitute a major portion of budget of a municipality for its safe and hygienic disposal of MSW.

The municipal solid waste is collected in community bins kept at different locations in the township according to the convenience of habitats and municipal authorities for its transportation to the final disposal point. In Third World countries these community bins are kept open at top and thus exposed to the climate. The composition and the quantity of MSW generated form the basis on which the management system needs to be planned, designed and operated. In India, MSW differs greatly with regard to the composition and hazardous nature, when compared to MSW in the western countries.

Characteristics of MSW

Management of municipal solid waste highly depends on the characteristics of the waste that is generated by the community. The typical average waste characteristics in different Asian cities are presented in Table-1.

Table 1. Typical average waste characteristics in different Asian cities

	Waste Categories (average percentage of wet weight)						
City	Bio-degradable	Paper	Plastic	Glass	Metal	Textiles & Leather	Inerts (ash, earth) & others
Bangkok	53	9	19	3	1	7	8
Dhaka	70	4.3	4.7	0.3	0.1	4.6	16
Hanoi	50.1	4.2	5.5	-	2.5	-	37.7
Jakarta	74	10	8	2	2	2	2
Karachi	39 10	7	-	2	1	9	32
Katmandu	68.1	8.8	11.4	1.6	0.9	3.9	5.3
Manali	49	19	17	-	6	-	9

For example, in south India the extensive use of banana leaves and stems in various functions results in a large organic content in the MSW. Also, it has been noticed that the percentage of recyclables (paper, glass, plastic and metals) is very low, because of rag pickers who segregate and collect the materials at generation sources, collection points and disposal sites. The composition and characteristics of MSW does not remain same throughout the year but it is highly influenced by the season. Therefore it is important to study the composition and characteristics of the MSW generated in different seasons .

The composition, characteristics and quantity generated of MSW from a township is a function of several parameters like- food

habit, season, living standard of people, commercial activities in the region etc. To device an effective management strategy for such waste it is important to study the general composition of the MSW generated as well as the variation in composition and characteristics with respect to the individual localities, income groups of different localities and seasons of the year.

METHODOLOGY

Step-I: Survey for Basic Information Regarding Waste Generation and its Disposal

Initially whole city area was surveyed to obtain basic information regarding the waste generation areas, collection points and disposal sites. The municipal solid waste is collected in community bins (fixed type) kept at different locations in the wards of the township according to the convenience of habitats and municipal authorities for its transportation to the final disposal point. The MSW is collected from different wards through trucks, tractor with trolley, airtech refuse collector and transported to the disposal points namely Sanjay Nagar, Gudhiyari, Ranwabhatha and Tikrapara.

Step-II: Collection of MSW Samples

In order to determine the composition and characteristic of MSW composite samples were collected from community dustbins as well as the final disposal points of MSW in polythene bags. The samples were collected by taking 5 grab samples of approximately 1 kg each from different depths as well as along the area of the dump. The grab samples were then mixed thoroughly. The samples of MSW were collected during different seasons (summer, rainy and winter).

Step-III: Analysis of MSW Samples for Composition and Characteristics

The mixed sample was then physically analyzed for its composition such as biodegradable, paper, plastic, glass, metals and inerts (dust, stone pieces and others) and expressed as % of total sample weight. Characteristics of the MSW were also determined like moisture content, calorific value, bulk density, dry density and waste generated per capita. Analysis of MSW was carried out as per the standard procedures (1). The procedure and concept adopted for determination of different characteristics is mentioned below:

Physical Shorting of MSW

Samples of MSW, collected from community bins were mixed thoroughly to make a composite sample for a specific location and physical shorting was done to separate out different ingredients such as- biodegradable (food waste, organics etc.), paper, plastic, glass, metals and inerts (dust, stone pieces and others). Weight of individual ingredient was taken and its fraction was represented in terms of percentage (%) of total wet weight of MSW sample taken (2).

Determination of Bulk Density

A metallic cubical of 45 cm x 45 cm x 45 cm was taken and the empty weight and volume of cubical was measured. Sample is filled up in the measuring cube and net weight of the sample was taken to determine the bulk density. The bulk density was obtained by dividing the weight of sample by volume of the container containing sample using Equation (1).

$$\gamma = \frac{W_2 - W_1}{V} \quad (1)$$

Where
γ = bulk density (gm/cm^3)
w_1 = wt of empty container in gm
w_2 = wt. of container with sample in gm
V = vol. of container (cm^3)

Determination of Moisture Content

Approximately 20gm of properly mixed sample of MSW was taken in dish and the initial wt. of the dish containing sample was taken. The dish containing sample was kept in oven at 105°C for 24 hrs. Final wt. of the sample is taken and moisture content is determined by following Equation (2)-

$$m = \frac{W_1 - W_2}{W_2} \text{ x } 100 \quad (2)$$

where,
m = moisture content (%)
w_1= initial wt. of sample (in gm)
w_2 = final wt. of sample (in gm)

Determination of Dry Density

Dry density was estimated using bulk density and moisture content by following Equation (3).

$$\gamma_d = \frac{\gamma}{1 + m} \quad (3)$$

where,
γ_d= dry density of substance (gm/cm^3)
γ = bulk density of substance (gm/cm^3)
m = moisture content (%)

Calorific Value

To determine the calorific value of MSW the standard procedure using bomb calorimeter and gram size sample was adopted. Digital bomb calorimeter was used to determine the calorific value of MSW (3).

A known amount of MSW is placed in the crucible. The crucible is then placed over a ring and a fine Magnesium wire touching the fuel sample is stretched across the electrodes. The lid is tightly screwed and the bomb is filled with oxygen upto 25atm pressure. The initial temperature is recorded. The electrodes are then connected to a 6V battery and the circuit is completed. As soon as the circuit is completed and current is switched on, the fuel in the crucible burns with the evolution of heat. Heat liberated by burning of the fuel increases the temperature of water and the maximum temperature attained is recorded and the calorific value is determined by following formula:

$$HCV = \frac{(W - w)(t_2 - t_1)}{m} \quad (4)$$

where:
HCV= higher Calorific value in Kcal/Kg
W= mass of water taken in calorimeter in gm

m= mass of MSW taken in calorimeter in gm
w= water equivalent of calorimeter, thermometer and stirrer in gm
t_1= *initial temperature of water in calorimeter in °C*
t_2= *final temperature of water in calorimeter in °C*

Step-IV: Analyzing the Variation in Composition and Characteristics of MSW

Management of municipal solid waste highly depends on the composition and characteristics of the waste that is generated by the community. The composition and characteristics of the waste is dependent on several aspects like- season, living standard, location etc. A variation in quantity and quality of MSW generated by the community was also analyzed to visualize the real situation.

RESULTS AND DISCUSSION

Composition of MSW in Different Seasons

Figure-1 shows the average composition of MSW in summer season. For summer season the average composition of biodegradable fraction is found to be 45.97 %, paper 4.05 %, plastic 5.08 %, glass 0.62%, metals 0.06%, textile & leather 0.72% and inert materials 43.51%.

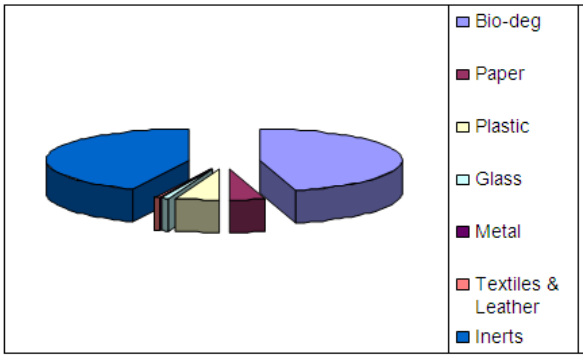


Fig 1. Average composition of MSW in summer season

Figure-2 shows the average composition of MSW in rainy season. For rainy season the average composition of biodegradable fraction is found to be 39.01 %, paper 4.66 %, plastic 3.26 %, glass 0.15%, metals 0.11%, textile & leather 0.61% and inert materials 52.19%.

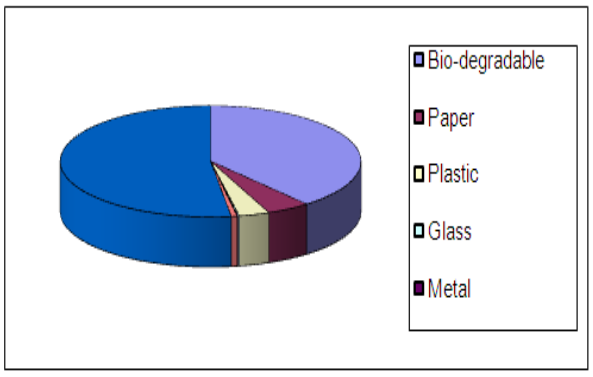


Fig 2. Average composition of MSW in rainy season

Figure-3 presents the average composition of MSW in winter season. For winter season the average composition of biodegradable fraction is found to be 52.77%, paper 4.42%, plastic 5.02%, glass 0.68%, metals 0.15%, textile & leather 0.90% and inert materials 36.08%.

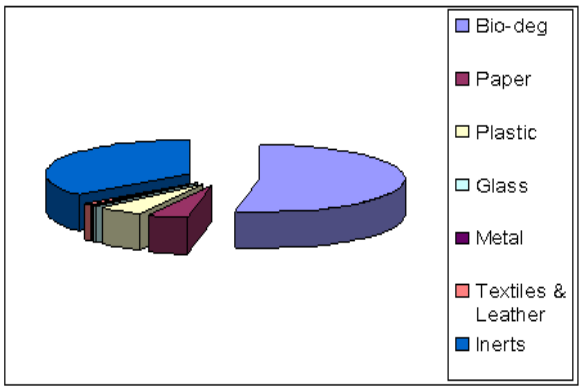
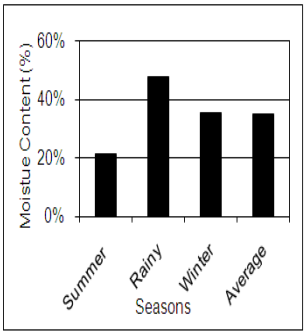


Fig 3. Average composition of MSW in winter season

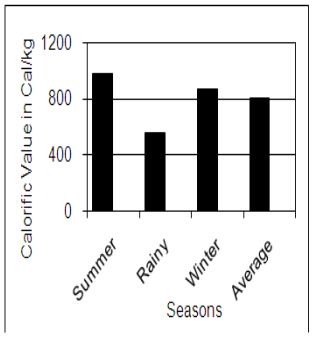
Comparison of Characteristics of MSW in Different Seasons

The different characteristics of MSW in different seasons as well as the yearly average of these characteristics are compared in Figure-4 (a) to Figure-4 (e). Figure -4 (a) shows that the total variation of moisture content was observed to be, 124 %. It was lowest in summer season (21.34 %) and highest in rainy season (47.87 %). Variation in Calorific value of MSW is shown in Figure 4(b) and it was observed to be varying from 560 Cal/kg in rainy season (lowest) to 974 Cal/kg in summer season (highest). A total variation of 73.9 % was observed in the values of calorific values.

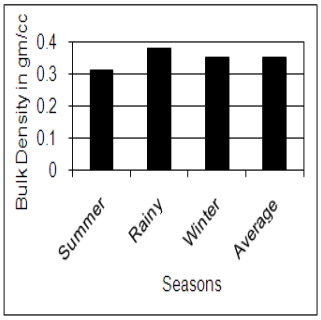
Figure-4 (c), shows that the Bulk density of MSW was 0.31 gm/cc in summer (lowest) and 0.38 gm/cc in rainy season (highest), a total variation of 22.5 % was observed. The variation of Dry density of MSW has been shown in Figure-4 (d) and was found to vary in a narrow range of 0.25 gm/cc in summer to 0.26 gm/cc in rainy and winter season, a total variation of only 4 % was observed. Variation of the per capita MSW generation in different seasons has been shown in Figure-.4 (e) and was observed 0.31 kg/day in rainy season to 0.45 kg/day in summer season, a total variation of 45.16 % was observed. The variations in characteristics of MSW with respect to different seasons are found to be significant for most of the parameters studied.



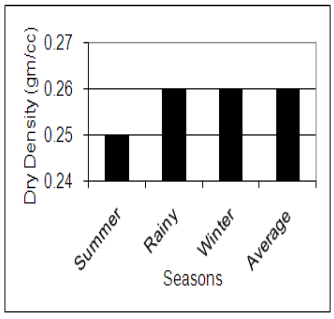
(a): Variation in moisture content



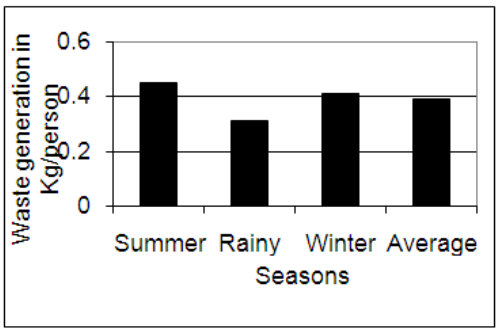
(b): Variation in calorific value



(c): Variation in bulk density



(d): Variation in dry density



(e): Variation in waste generated per Capita

Fig 4 (a) to (e): Seasonal variation in MSW Characteristics

CONCLUSIONS

- The yearly average composition of MSW of Raipur city has biodegradable 45.92 %, paper 4.38 %, plastic 4.45 %, glass 0.48 %, metals 0.11 %, textile& leather 0.90 % and inert material 43.93 %.
- The MSW of Raipur city shows a seasonal variation of 124 % in moisture content, 73.9 % in calorific value, 22.5 % in bulk density, 4 % in dry density and 45.16 % in generation of waste per person per day.
- The seasonal variation in characteristics of MSW was found to be in a wide range of 4-125 % so none of the methods of MSW management (i.e. dumping on land, composting, recycling and recovery, burning and energy generation) alone can be sufficient for efficient management of MSW.
- For comprehensive management of this MSW, a proper combination of recycling and recovery, composting, energy generation and dumping on land should be adopted.
- The seasonal variation in characteristics of MSW also gives an idea about the arrangements to be made for collection, transportation and disposal of different quantity of MSW generated in different seasons.

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