Journal Of Harmonized Research (JOHR)

Journal Of Harmonized Research in Engineering
6(2), 2017, 18-22

ISSN 2347 – 7393

Review Article

COMPOSITION OF SOLID WASTE- A GENERAL VIEW

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Abstract: Municipal Solid Waste Management or MSWM is the burning issue in India as well as other developed countries. There are various challenges in MSWM in urban India which is the motivation of the present study. Due to the urbanization municipal solid waste (MSW) generation is enhanced and instinctive handling of MSW degrades the urban environment and causes health hazards. In this paper, an attempt is made to depict the major problems of MSWM, in addition to a comprehensive review of MSW generation, its characterization, collection, and treatment options as practiced in India. The current practice of MSWM in Indian states and important cities of India is also reported.

Keywords: Urbanization; Municipal Solid Waste; biodegradable; recycling

In the municipal solid waste stream, waste is broadly classified into organic and inorganic. The Municipal Wastes generated from residential, commercial, institutional segments get mixed up with traces of other wastes from hospital, industrial and municipal services including construction & demolition wastes. This mix up is declining with stricter enforcement of legislation. The rate of waste generation is an index of socio-economic development and economic prosperity of the region. Increasing industrialization and raising incomes lead to greater use of resources and waste composition is influenced by factors such as extent of urbanization, standard of living and climate. Thus, waste quantities as well as composition are inextricably linked to the vibrancy of economic activity and resource consumption pattern of the society which generates the waste. Solid waste are generated from various sources viz. residential and commercial areas, institutions, industries, construction and demolition activities, municipal services, agricultural activities, treatment plants and special category sources. Solid waste of

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Received on: September 2016
Accepted after revision: May 2018
Downloaded from: www.johronline.com

each municipal corporation is diversified in nature and highly dependent on the type of area from where it has collected. The composition of urban MSW in India is 51% organics, 17.5% recyclables (paper, plastic, metal, and glass) and 31 % of inerts (Table 1). The moisture content of urban MSW is 47% and the average calorific value is 7.3 MJ/kg (1745 kcal/kg). The composition of MSW in the North, East, South and Western regions of the country varied between 50-57% of organics, 16-19% of recyclables, 28-31% of inerts and 45-51% of moisture (Table 1). The calorific value of the waste varied between 6.8-9.8 MJ/kg (1,620-2,340 kcal/kg). Solid Wastes are categorized into municipal wastes, hazardous wastes, medical wastes and radioactive wastes. Following table (Table 1) depicts the sources and types of Municipal Solid Waste:

Table: 1

Sources	Typical waste generators	Components of solid waste
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, glass, metals, ashes, special wastes (bulky items, consumer electronics, batteries, oil, tires) and household hazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government center, hospitals, prisons	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Municipal services	Street cleaning, landscaping, parks, beaches, recreational areas	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational areas

For example, following table (Table 2) shows the percent composition of solid waste generation in Begumpura of Aurangabad city, India:

Table: 2

House No.	**Waste generation quantity in grams**						
	Vegetable and food waste	**Paper**	**Plastic**	**Glass/ceramics**	**Metal**	**Fine earth ash**	**Miscellaneous**
1	26.4	9.2	5.1	3.4	4.8	48.7	1.4
2	27.2	8.4	4.9	3.8	4.5	48.4	2.8
3	28.1	8.1	4.2	3.7	4.7	47.9	3.3
4	27.9	7.5	4.9	4.1	4.6	48.5	2.5
5	28.5	8.7	4.6	3.8	4.8	47.9	1.7
6	28.7	8.2	4.1	3.7	2.7	45.9	6.7
7	28.4	7.9	4.2	3.1	3.5	47.6	5.3
8	29.3	8.4	4.1	3	3.1	45.6	6.5
9	29.8	8.4	4.4	3.9	3.7	47.4	2.4
10	28.5	7.8	5.4	3.9	4.3	46.4	3.7
11	28.4	8.3	5.1	3.2	5.4	46.9	2.7
12	29.5	7.8	4.1	3.9	4.2	46.7	3.8
13	28.9	8.5	4.4	3.4	4.8	48.7	1.3
14	27.8	8.2	4.1	3.8	4.3	46.4	5.4
15	28.2	7.9	3.3	4.1	4.2	47.9	4.4
16	28.6	7.5	3.7	4.3	3.9	45.4	6.6
17	28.2	7.9	4.1	4.5	3.7	46.9	4.7
18	27.9	8.1	5.3	3.7	2.1	46.2	6.7
19	28.1	7.8	4.4	2.9	3.5	47.2	6.1
20	27.6	7.5	5.4	3.5	3.5	46.1	6.4

21	28.8	7.8	5.2	4.1	3.8	47.8	2.5
22	28.5	7.8	5.4	3.9	4.3	46.4	3.7
23	27.6	9.1	4.9	3.3	5.1	47.1	2.9
24	28.5	8.2	4.6	4.1	4.2	45.9	4.5
25	28.5	7.8	5.4	3.9	4.3	46.4	3.7
Average	**28.31**	**8.11**	**4.61**	**3.72**	**4.08**	**47.05**	**4.06**
SD	**1.08**	**0.44**	**0.59**	**0.40**	**0.75**	**0.98**	**1.75**

The quantity of waste paper in India, is much less, as even the quantity thrown away is picked up by people for its use as a fuel and also for packaging of materials / food sold by road side hawkers. The plastics, rubber and leather contents are lower than the paper content, and do not exceed 1% except in metropolitan cities. The metal content is also low, (less than 1%). These low values are essentially due to the large scale recycling of these constituents .Paper is recycled on a priority basis while plastics and glass are recycled to a lesser extent (Joseph, 2002). The biodegradable fraction is quite high in Indian MSW, essentially due to the habit of using fresh vegetables. The ash and fine earth content of Indian MSW is high due to the practice of inclusion street sweepings, drain silt, and construction and demolition debris in MSW. Many reports, papers and data bank in India do not give estimation of what waste composition/quality had been in the past, present and what would be in future, other than projecting the huge and daunting increase in sheer quantities. Rag picking is one activity that is feared to be causing a steep decrease in the heat value of the waste because of implied recycling activity. What is business for scrap and recycling today may not be worth in the course of time and in the cause of economic growth and not bound to maintain its efficiency if at all it is now. It is worth examining the changes in the composition of waste in India in the last two decades.

Table 3

Component	**% of Wet Weight**	
	1971-73(40 cities)	1995 (23 cities)
Paper	4.14	5.78
Plastics	0.69	3.90
Metals	0.50	1.90
Glass	0.40	2.10
Rags	3.83	3.50
Ash and fine	49.20	40.30
Total	41.24	41.80

Compostable Matter		
Cal. Value Kcal/kg	800-1100	<1500
CN Ratio	20-30	25-40

The table 3 gives the changing composition of Municipal Waste over the last two decades and is attributed to the changing life styles and increasing consumerism.

As countries develop and become more urbanized, the waste composition undergoes a change. Waste composition is influenced by many factors, such as level of economic development, cultural norms, geographical location, energy sources, and climate. As a country urbanizes and populations become wealthier, consumption of inorganic materials (such as plastics, paper, and aluminum) increases, while the relative organic fraction decreases. Generally, low and middle-income countries have a high percentage of organic matter in the urban waste stream, ranging from 40 to 85% of the total. Paper, plastic, glass, and metal fractions increase in the waste stream of middle- and high-income countries. Climate can also influence waste generation in a city, country, or region. For example, in Ulan Bator, Mongolia, ash makes up 60% of the MSW generated in the winter, but only 20% in the summer (UNEP/GRID-Arendal 2004). Precipitation is also important in waste composition, particularly when measured by mass, as un-containerized waste can absorb significant amounts of water from rain and snow. Humidity also influences waste composition by influencing moisture content. In India the variation in the parameters is very wide and thus the quality as well as quantity estimation for a city or state cannot 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.

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. 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 per capita waste generation rate is strongly correlated to the gross domestic product (GDP) of a country (Table 2). Per capita waste generation is the amount of waste generated by one person in one day in a country or region. The waste generation rate generally increases with increase in GDP. High income countries generate more waste per person compared to low income countries due to reasons discussed in further sections. The average per capita waste generation in India is 370 grams/day as compared to 2,200 grams in Denmark, 2,000 grams in US and 700 grams in China (12) (13) (14). Generation of MSW has an obvious relation to the population of the area or city, due to which bigger cities generate more waste. The metropolitan area of Kolkata generates the largest amount of MSW (11,520 TPD or 4.2 million TPY) among Indian cities.

Among the four geographical regions in India, Northern India generates the highest amount of MSW (40,500 TPD or 14.8 million TPY), 30% of all MSW generated in India; and Eastern India (23,500 TPD or 8.6 million TPY) generates the least, only 17% of MSW generated in India. Among states, Maharashtra (22,200 TPD or 8.1 million TPY), West Bengal (15,500 TPD or 5.7 million TPY), Uttar Pradesh (13,000 TPD or 4.75 million TPY), Tamil Nadu (12,000 TPD or 4.3 million TPY) Andhra Pradesh (11,500 TPD or 4.15 million TPY) generate the highest amount of MSW. Among Union Territories, Delhi (11,500 TPD or 4.2 million TPY) generates the highest and Chandigarh (486 TPD or 177,400 TPY) generates the second highest amount of waste. Materials in MSW can be broadly categorized into three groups, Compostables, Recyclables and Inerts. Compostables or organic fraction comprises of food waste, vegetable market wastes and yard waste. Recyclables are comprised of paper, plastic, metal and glass. The fraction of MSW which can neither be composted nor recycled into secondary raw materials is called Inerts. Inerts comprise stones, ash and silt which enter the collection system due to littering on streets and at public places.

Waste composition dictates the waste management strategy to be employed in a particular location. Organics in MSW are putrescible, and are food for pests and insects and hence need to be collected and disposed off on a daily basis. The amount of recyclables like paper and plastic in MSW dictates how often they need to be collected. Recyclables represent an immediate monetary value to the collectors. Organics need controlled biological treatment to be of any value, however due to the general absence of such facilities, organics do not represent any direct value to informal collectors. A major fraction of urban MSW in India is organic matter (51%). Recyclables are 17.5 % of the MSW and the rest 31% is inert waste. The average calorific value of urban MSW is 7.3 MJ/kg (1,751 Kcal/kg) and the average moisture content is 47% (Table 6). It has to be understood that this composition is at the dump and not the composition of the waste generated. The actual percentage of recyclables discarded as waste in India is unknown due to informal picking of waste which is generally not accounted. Accounting wastes collected informally will change the composition of MSW considerably and help estimating the total waste generated by communities.

The large fraction of organic matter in the waste makes it suitable for aerobic and anaerobic digestion. Significant recyclables percentage after informal recycling suggests that efficiency of existing systems should be increased. Recycling and composting efficiency are greatly reduced due to the general absence of source separation. Absence of source separation also strikes centralized aerobic or anaerobic digestion processes off the list. Anaerobic digestion is highly sensitive to feed quality and any impurity can upset the entire plant. Aerobic digestion leads to heavy metals leaching into the final

compost due to presence of impurities and makes it unfit for use on agricultural soils. In such a situation the role of waste to energy technologies and sanitary landfilling increases significantly. This is due to the flexibility of waste-to-energy technologies in handling mixed wastes. Sanitary landfilling needs to be practiced to avoid negative impacts of open dumping and open burning of wastes on public health, and on air, water and land resources. Therefore, increasing source separation rates is always the long term priority. Following table (Table 4) shows the composition of municipal solid waste in different region of India:

Table 4

Region/ City	MSW (TPD)	Compostable (%)	Recyclables (%)	Inerts (%)	Moisture (%)	Cal. Value (Mj/kg)	Cal. Value (kcal/kg)
Metros	51,402	50.89	16.28	32.82	46	6.4	1,523
Other cities	2,723	51.91	19.23	28.86	49	8.7	2,084
East India	380	50.41	21.44	28.15	46	9.8	2,341
North India	6,835	52.38	16.78	30.85	49	6.8	1,623
South India	2,343	53.41	17.02	29.57	51	7.6	1,827
West India	380	50.41	21.44	28.15	46	9.8	2,341
Overall Urban India	130,000	51.3	17.48	31.21	47	7.3	1,751

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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