MUNICIPAL SOLID WASTE GENERATION, MANAGEMENT AND ADMINISTRATIVE FRAMEWORKS

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Abstract

In general, the term „waste" implies to a substance, which has no longer any economic value. The composition, nature and properties of wastes depend largely on the source from where it is generated. For the purpose of classification, wastes in general can be subdivided on the basis of its physical state /nature (solid, liquid, gaseous) or on sources (urban and rural) or even nature of origin – agro wastes, industrial wastes, trade wastes, domestic wastes, etc. All these classifications are however, interdependent. This study focuses on urban solid wastes. With the progress of civilisation, the solid wastes generated and related problems have become more complex.Waste is defined as any material that is not useful and does not represent any economic value to its owner, the owner being the waste generator. Depending on the physical state of waste, wastes are categorized into solid, liquid and gaseous. Solid Wastes are categorized into municipal wastes, hazardous wastes, medical wastes and radioactive wastes. Managing solid waste generally involves planning, financing, construction and operation of facilities for the collection, transportation, recycling and final disposition of the waste. This study focuses only on the disposal of municipal solid waste (MSW), as an element of overall municipal solid waste management or just solid waste management (SWM).

Keywords: Municipal Solid Waste, dumping, Frameworks, Generation

Waste disposal and pollution are inextricably linked. The term pollution describes both the act of polluting and the consequences of that act. Waste describes unwanted residues that are usually perceived to be of negative value. Pollution can be defined as "the introduction into the natural environment by humans the substances, materials or energy that cause hazards to human health, harm to living resources and ecological systems, damage to structures and amenities or that interfere with the legitimate uses of the environment" (Braber, 1995). It is implicit in the definition that pollution only describes situations where unwanted effects occur. The majority of waste disposal situations involve pollution of one kind or another. Thus the solid wastes one of the serious problems in developing countries situations need eco-friendly treatment options. This has become a major environmental issue in India. The quantity of waste generated per capita is estimated to increase at a rate of 1-1.33% annually in India (Shekdar, 1999). This is largely because of rapid population growth and economic development in the country. Thus there have been significant increases in USW generation in India during the last few decades. This enormous increase in solid waste generation will have significant impacts in terms of the land required for disposing this waste as well as on methane emissions. The burden that the increase in solid waste generation would impose is evident from the fact that the cumulative requirement of land for disposal of USW in India would amount to around 1400 km2 by 2047 (Singhal and Pandey, 2001). Solid wastes generation, urbanization and population growth are highly inter-related and will compete in the process of land acquisition. Improper waste disposal practices in the past have created several problems as well as aesthetically unpleasant sites. Two problems are foremost in India and in the other developing countries:

- Absence of adequate dumping sites and
- The absence of appropriate primary treatment of USW.

The sustainable option thus lies in the reuse of these wastes by non-polluting and environmentally benign technologies while simultaneously deriving economic and material benefits in the process.

Concerns about sustainable development and environmentally sound policies have been growing considerably everywhere in the last decades. Waste production and management are among the issues that need to be seriously considered and dealt with.

In many countries waste generation has been growing as a function of population and economic growth, besides unsustainable patterns of consumption and production. While developed countries usually have large amounts of resources available for dealing with solid waste problems, in developing countries the situation is often aggravated by lack of funds (Deshmukh et al, 2002).

Table 1.1: Status of urban solid waste generation in metro cities:

City	**Bangalore**	**Kolkata**	**Chennai**	**Delhi**	**Mumbai**
Area (km2)	226	187	174 1,	484	437
Population (Million)	5.31	6.00	5.00	12.20	12.50
USW generation(Tons/day)	2200	3100	3050	6000	6000
USW/capita (kg/d)	0.41	0.52	0.61	0.49	0.48
Garbage pressure(t/km2)	9.73	16.55	17.53	4.04	13.71

Source: TEDDY, 2002

Physical Characteristics of USW Composition

USW in India can be broadly categorized into organic matter (putrescibles), recyclables and ash materials. Of these three, the organic waste component has remained constant over the past decades at the level of 40% (according to EPTRI, 1995, In India 42.5% was the total compostable matter). The ratio between the other two components has changed in past decades and likely to show further change in the future (Shuchi *et al.*, 1998). This is mostly due to the occurrence of shift in the usage of recyclable materials namely plastic, paper etc (results of rag picking). Within India, there is a vast difference in physical characteristic of garbage generated by different cities is given in Table 1.2. Paper is the main source of variation and increases with increase in the population. In the Indian context, paper waste generally falls in the range of 3-7%, when the waste reaches the disposal site (Asnani, 1998). The plastic and metal contents are lower than the paper content and do not exceed 1% except in metropolises. This is mainly due to the fact that large-scale recycling of these constituents takes place in most medium and large cities (as a results of rag picking). The biodegradable fraction is quite high, arising from the practice of using fresh vegetables in India.

Table 1.2: Physical characteristics of solid waste from some cities in India*(in %)*

Cities	Paper	Plastic	Metal	Glass	Ash & Earth	Total Compostable
Calcutta	3.18	0.65	0.66	0.38	34.00	47.00
Delhi	6.29	0.85	1.21	0.57	36.00	35.00
Chennai*	5.90	-	0.70	-	16.35	56.24
Nagpur	1.88	1.35	1.33	1.34	41.42	34.81
Bangalore	4.00	2.00	-	1.00	15.00	78.00
Bombay	10.00	2.00	3.6	0.2	45.60	40.00

*A.P. Jain, 1994;

Source; Background information for Conference of Mayors and Municipal Com-missioners, Urban and Industrial Energy Group, Ministry of Non- Conventional Energy Sources, New Delhi,

1. Cited from: http://www.cleantechindia.com/eicnew/techoption/energy.html, Source: India's Development Report, 1997

2. Cited from: http://mospi.nic.in/comenv2000tab7.4.3.htm

3. 20th WEDC Conference, A.P. Jain, 1994

Chemical Characteristic of Waste

Knowledge in chemical composition is essential in selecting proper treatment options for the urban wastes. Chemical analysis of Indian wastes carried out by NEERI, India and others has shown that total nitrogen varies from 0.56% to 0.71%, phosphorous from 0.52% to 0.82%, potassium from 0.52% to 0.83% and C/N ratio is between 21- 31%. Hence the calorific value has been found to be ranging between 800 and 1010 Kcal/kg and density of waste between 330 and 560 kg/m3 (Asnani, 1996).

Comparison of USW Composition with Other Countries

Comparative physical characteristic of solid wastes produced by cities in developed countries versus that found in Indian cities are given in Table 1.3. This table clearly shows that the quantity of waste produced in developing countries is lesser than that in developed countries. Unlike in developed countries, the wastes of Indian cities have a high fraction of degradable organic matter, from 35 to 75%. This fraction of garbage has a high energy potential (Sharma, 2001), compared to only 12% to 15% of U.S.A and U.K (Table 1.3).

Table 1.3: : Comparative study of waste production (as percentages of total weight) in India and Developed Countries

Particulars / Component	India	UK	USA	Switzerland	Japan
USW generated (kg/day)	0.3-0.6	0.82	2.5	0.6	1.47*
Putrescible waste (%)	31-67	13.00	15.0	14.5	36.9
Paper (%)	0.25-8.75	50.00	54.5	33.5	24.8
Glass (%)	0.07-1.0	6.00	9.1	8.5	3.3
Rags (%)	0.3-7.3	3.00	2.6	3.0	3.6
Plastics (%)	0.15-0.7	1.00	1.7	2.0	2.2
Carbon/nitrogen ratio (C:N)	25-40	44.00	50.0	40.9	NA
Density (kg/m3)	250-500	128.0	NA	NA	NA

NA-not applicable; * Source: CPHEEO, 2000

Most of the countries in the world utilized the option of landfill for the disposal of wastes for a long time. The degradable component of the wastes in the landfill gives rise to the liquid and gaseous end products such as leachate and biogas (Jaffrin *et al.*, 2003). The gaseous products of waste decomposition pollute the air and contribute to global warming. Similarly the liquid end product, called leachate, also contributes air pollution (by means of noxious odors) and ground water pollution (by percolation). These problems are clearly outlined elsewhere (IEA bioenergy update, 2004) converting organic wastes into a useful form of energy or compost reduces various environmental impacts. The composting route results in uncontrolled release of CO_2 into the atmosphere without capturing energy of the waste (Yu *etal.*, 2002). Of the above three treatment methods, energy recovery seems to be effective by offering the following advantages:

- The total quantity of waste is reduced by nearly 60-90% depending upon the waste composition and the adopted technology (anaerobic digestion).
- Demand for the land, which is already scarce in cities for the land filling, is reduced.
- The cost of transportation of waste to far away landfill sites is also reduced.

Environmentally sound waste management must go beyond the mere safe disposal. It should include minimization actions, reuse and recycling activities, proper treatment and finally safe disposal. But its success is highly dependent on an informed and participatory public. Public participation is considered to be an important part of waste management strategies.

Inherent human desire in resources consumption governs the waste generation capacity. The municipal solid wastes (MSW) quantity and composition therefore depend on population density, source diversity and the income of the people in the locality. With increase in population, economic activity and the income, the MUNICIPAL SOLID WASTE quantity and composition including the non-biodegradable and hazardous wastes is bound to increase. The evolutionary waste quantity and characteristics accordingly challenge the municipal authorities in management, demanding more and more resources and technological capability. In developing countries where resources and capacity is constrained, the challenges thus become serious.

Integrated solid waste management is an approach that uses a range of methods and practices to handle municipal solid waste (as well as industrial and agricultural waste). It embraces waste avoidance and minimization methods, reuse and recycling programs, collection of refuse, treatment methods (as for example incineration and composting) and disposal.

Different steps and activities which are part of integrated municipal waste management strategies are discussed, followed by a study that shows how Municipal Solid Waste Manage, in India, has been approaching waste management challenges in urban areas.

According to Chapter 7 in Agenda 21, the sustainability of urban development is defined by many parameters relating to the availability of water supplies, air quality and the provision of environmental infrastructure for sanitation and waste management (UNSD, 1992).

With the 74th amendment of the Constitution of India in 1992, municipal authorities or Urban Local Bodies (ULBs) in the country have been recognized as a third tier of Government. The 12th schedule of the Constitution has laid down the functions envisaged to be performed by the ULBs. One among those functions is Municipal Solid Waste (MSW) management. Although MSW management is a mandatory function of each ULB, this aspect of civic administration has not received due attention. With ever increasing MSW quantity due to rapid urbanization and change in the lifestyle, the problem of MSW management become more acute and causing serious problems of health and environment. Regarding this, public interest litigation (PIL) had been filed in the Honorable Supreme Court of India in 1996 and, to direct the ULBs as well as the Government of India and State Governments to improve MSW management practices, Barman committee was appointed to evaluate all aspects of MSW management. On the basis of report submitted by Barman Committee in March 1999, MSW (Management and Handling) Rules, 2000 (also referred to as the "Rules") were issued by the Central Government in exercise of its powers under the Environment (Protection) Act, 1986. The Rules have substantially incorporated the recommendations made by the committee and attempts to delineate responsibilities and bestow specific duties on the citizens as well as the ULBs for effective MSW management system.

Appropriate waste management plays an important role towards promoting a sustainable urban development within human settlements. With that in mind, and knowing that in most developing countries the highest urban population growth rates occur in the low-income areas, the goal of this study is to analyze the current waste management situation in Mohali, Punjab (India).

In current scenario the acute problem of Municipal Solid Waste (MSW) management is enhancing day by day due to rapid Industrilization, urbanization and change in the lifestyle, and also becoming a serious threat to health and environment.

Public responsibility sharing and specific waste management institutional tools also are limited. Requirement of introduction of 3Rs (Reduce, Reuse and Recycle) as effective steps in the solid waste management systems, but did not identify the viable 3R options. The prevailing predominant solid wastes reduction practice is separation of valuable wastes, mostly metals and beer cans and bottles, by the waste dealers.

If compared with the size of urban areas and the waste quantities in the region, Mohali solid wastes is so small that it should be manageable. It should be manageable with appropriate policies and institutional setup in place. Not necessarily requiring sophisticated and expensive technologies. This study therefore aims to analyze management gaps in the present urban solid waste management system of Mohali and identify 3R options, mainly applicable low cost policy options. Anything that improves the situation in Mohali should be applicable to other urban settlements in Mohali is an adjoing area of chandigarh which is the capital of Haryana & Punjab State of India and the biggest urban settlement.

Legal and Administrative Framework

The 1972 United Nation Conference on Human Development at Stockholm influenced the need for a well-developed legal mechanism to conserve resources, protect the environment and ensure the health and well being of the people in India. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. As a result, our country now has a fairly comprehensive set of environmental legislation aimed at ensuring that the development process meets the overall objective of promoting sustainability in the long run. Moreover, the Indian Constitution has also incorporated specific articles to address environmental concerns through the 42nd Constitutional Amendment of 1976. As stated in the Constitution of India, it is the duty of the state (Article 48 A) to ‘protect and improve the environment and to safeguard the forests and wildlife of the country’. It imposes a duty on every citizen (Article 51 A) ‘to protect and improve the natural environment including forests, lakes, rivers and wildlife’. Reference to the environment has also been made in the Directive Principles of State Policy as well as the Fundamental Rights.

Per Capita MSW Generattion

The per capita waste generation rate is strongly correlated to the gross domestic product (GDP) of a country (Table 1.7). 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.

Table 1.7: Comparison between the per capita MSW generation rates in Low, Middle and High Income Countries

Country	**Per Capita Urban MSW Generation (kg/day**	
	1999	**2025**
Low Income Countries	0.45 - 0.9	0.6 - 1.0
Middle Income Countries	0.52 - 1.1	0.8 - 1.5
High Income Countries	1.1 - 5.07	1.1 - 4.5

Waste generation rate in Indian cities ranges between 200 - 870 grams/day, depending upon the region's lifestyle and the size of the city. The per capita waste generation is increasing by about 1.3% per year in India (7).

The composition of urban MSW in India is 51% organics, 17.5% recyclables (paper, plastic, metal, and glass) and 31 % of inerts (Table 6). 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 6). The calorific value of the waste varied between 6.8-9.8 MJ/kg (1,620-2,340 kcal/kg).

Table 1.8: Highest and Lowest Waste Generation and Waste Generation Rates Among Metros, Class 1 cities, States, UTs, and North, East, West, South regions of India

Particulars	**Value/ city**	**Waste Generation (TPD)**		**Per Capita Waste Generation (kg/day)**	
		Low	**High**	**Low**	**High**
Metros	Value	3344	11520	0.445	0.708
	City	Greater Bangalore	Greater Kolkata	Greater Bangalore	Chennai
Class 1 Cities	Value	317	2602	0.217	0.765
	City	Rajkot	Pune	Nashik	Kochi

All Cities	Value	5	11520	0.194	0.867
	City	Kavarati	Kolkata	Kohima	Port Blair
State	Value	19	23647	0.217	0.616
	City	Arunachal Pradesh	Maharashtra	Manipur	Goa
Union Territories (UT)	Value	5	11558	0.342	0.867
	City	Lakshadweep	Delhi	Lakshadweep	Andaman & Nicobar
Regions	Value	696	88800	0.382	0.531
	Region	East	West	East	West

Cities in Western India were found to be generating the least amount of waste per person, only 440 grams/day, followed by East India (500 g/day), North India (520 g/day), and South India. Southern Indian cities generate 560 grams/day, the maximum waste generation per person. States with minimum and maximum per capita waste generation rates are Manipur (220 grams/day) and Goa (620 grams/day). Manipur is an Eastern state and Goa is Western and both are comparatively small states. Among bigger states, each person in Gujarat generates 395 g/day; followed by Orissa (400 g/day) and Madhya Pradesh (400 grams/day). Among states generating large amounts of MSW per person are Tamil Nadu (630 g/day), Jammu & Kashmir (600 g/day) and Andhra Pradesh (570 g/day). Among Union Territories, Andaman and Nicobar Islands generate the highest (870 grams/day) per capita, while Lakshadweep Islands (340 grams/day) generates the least per capita. Per capita waste generation in Delhi, the biggest Union Territory is 650 g/day.

The Census of India classifies cities and towns into 4 classes, Class 1, Class 2, Class 3, and Class 4, depending upon their population (Table 4). Most of the cities studied during this research fell under Class 1. For the purpose of this study, these Class 1 cities were further categorized as Metropolitan, Class A, Class B, etc, until Class H depending upon the population of these cities. This finer classification allowed the author to observe the change in waste generation closer. However, the waste generation rates did not vary significantly between Class A, B, C, D, E, F, G & H cities. They fell in a narrow range of 0.43-0.49 kg/person/day. They generated significantly less MSW per person compared to the six metropolitan cities (0.6 kg/day). The per capita waste generation values of Class 2, 3 and 4 towns calculated in this report are not expected to represent respective classes due to the extremely small data set available. Data for only 6 out of 345 Class 2 cities, 4 out of 947 Class 3 cities and 1 out of 1,167 class 4 towns was available. Despite the lack of data in Class 2, 3, and 4 towns, the 366 cities and towns represent 70% of India's urban population and provide a fair estimation of the average per capita waste generation in Urban India (0.5 kg/day).

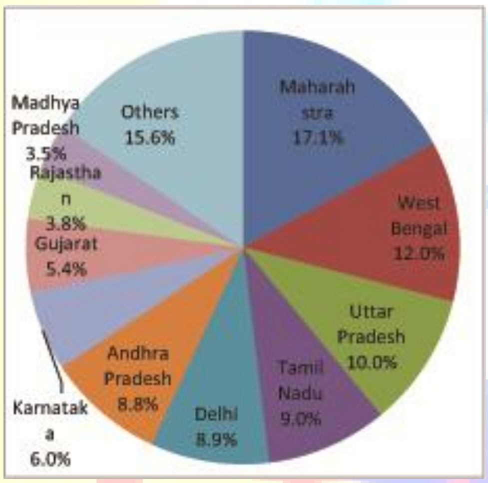
Table 1.9: Per Capita Waste Generation Rate depending upon the Population Size of Cities and Towns

Original Classification	Classification for this Study	Population Range (2001 Census)		No. of Cities	Per Capita kg/day
	Metropolitan	5,000,000	Above	6	0.605
	Class A	1,000,000	4,999,999	32	0.448
Class 1	Class B	7,00,000	999,999	20	0.464
	Class C	5,00,000	699,999	19	0.487
	Class D	4,00,000	499,999	19	0.448
	Class E	3,00,000	399,999	31	0.436
	Class F	2,00,000	299,999	58	0.427
	Class G	1,50,000	199,999	59	0.459
	Class H	1,00,000	149,999	111	0.445
Class 2	-	50,000	99,999	6	0.518
Class 3	-	20,000	49,999	4	0.434
Class 4	-	10,000	19,999	1	0.342
	Total	-	-	366	-

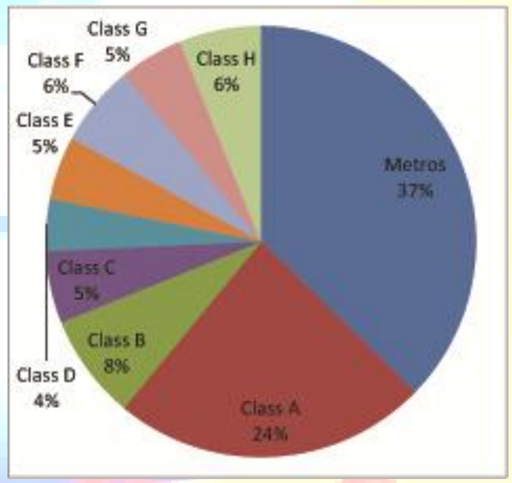
MSW Generation

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.



Share of States and Union Territories in Urban MSW Generated



Share of Different Classes of Cities in Urban MSW Generated

MSW Composition

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.

Table 1.10: Components and Waste Materials in MSW

MSW components	Materials
Compostable	Food waste, landscape and tree trimmings
Recyclables	Paper, Cardboard, Plastics, Glass, Metals
Inert	Stones and silt, bones, and other inorganic materials

Composition of Urban MSW in India

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.

Table 1.11: Sources and Types of Municipal Solid Waste

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

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.

Table 1.12: Composition of MSW in India and Regional Variation

Region/ City	MSW (TPD)	Compo-stables	Recy-clables	Inerts	Moisture	Cal. Value (MJ/Kg)	Cal. Value (kcal/Kg)
Metros	51402	50.89	16.28	32.82	46	6.4	1523
Other Cities	2723	51.91	19.23	28.86	49	8.7	2084
East India	380	50.41	21.44	28.15	46	9.8	2341
North India	6835	52.38	16.78	30.85	49	6.8	1623
South India	2343	53.41	17.02	29.57	51	7.6	1827
West India	380	50.41	21.44	28.15	46	9.8	2341
Overall Urban India	130000	51.3	17.48	31.21	47	7.3	1751

Percentage of Recyclables and Informal Recycling

A significant amount of recyclables are separated from MSW prior to and after formal collection by the informal recycling sector. The amount of recyclables separated by the informal sector after formal collection is as much as 21% . The amount of recyclables separated prior to collection is generally not accounted for by the formal sector and could be as much as four times the amount of recyclables separated after formal collection. Comparing the percentage of recyclables in MSW in metro cities with that in smaller cities clearly shows the increased activity of informal sector in metros and other large cities. Increased presence of informal sector in large cities explains the huge difference in recyclables composition between large and small cities, observed by PerinazBhada, et al.. In metro cities, which generally have a robust presence of informal recycling sector, the amount of recyclables at the dump is 16.28%, whereas in smaller cities where the presence of informal sector is smaller, the composition of recyclables is 19.23%. The difference of 3% in the amount of recyclables at the dump indicates the higher number of waste pickers and their activity in larger cities.

Solid Waste Management (SWM)

A solid waste management (SWM) system includes the generation of waste, storage, collection, transportation, processing and final disposal. This study will focus on disposal options for MSW in India.

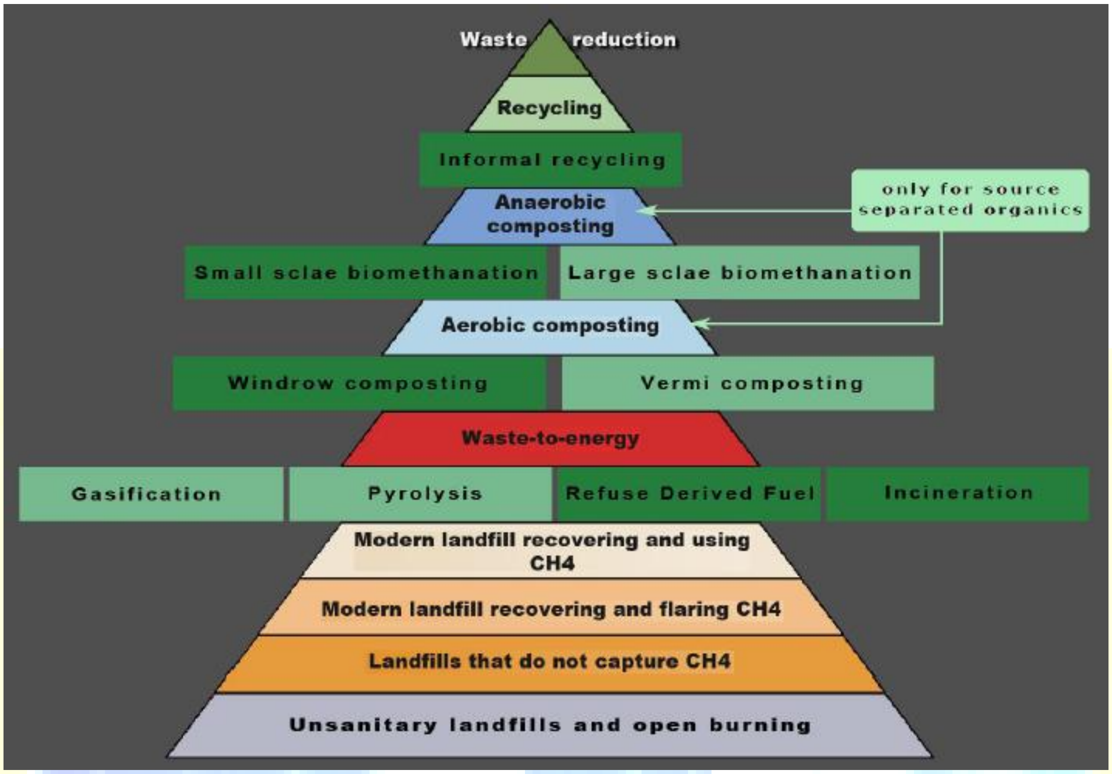
Agricultural and manufactured products of no more value are discarded as wastes. Once items are discarded as waste, they need to be collected. Waste collection in most parts of the world is centralized and all kinds of waste generated by a household or institution are collected together as mixed wastes.

Solid waste management (SWM) is a basic public necessity and this service is provided by respective urban local bodies (ULBs) in India. SWM starts with the collection of solid wastes and ends with their disposal and/or beneficial use. Proper SWM requires separate collection of different wastes, called source separated waste collection. Source separated collection is common in high income regions of the world like Europe, North America and Japan where the infrastructure to transport separate waste streams exists. Most centralized municipal systems in low income countries like India collect solid wastes in a mixed form because source separate collection systems are non-existent. Source separated collection of waste is limited by infrastructure, personnel and public awareness. A significant amount of paper is collected in a source separated form, but informally. In this report, unmixed waste will be specially referred to as source separated waste, in all other cases municipal solid waste (MSW) or solid waste would refer to mixed wastes.

Indian cities are still struggling to achieve the collection of all MSW generated. Metros and other big cities in India collect between 70- 90% of MSW. Smaller cities and towns collect less than 50% (6). The benchmark for collection is 100%, which is one of the most important targets for ULBs at present. This is a reason why source separated collection is not yet in the radar.

Hierarchy of Sustainable Waste Management

The Hierarchy of Sustainable Waste Management (Figure 10) developed by the Earth Engineering Center at Columbia University is widely used as a reference to sustainable solid waste management and disposal. This report is presented in reference to this hierarchy. For the specific purpose of this study, "Unsanitary Landfilling and Open Burning" has been added to the original hierarchy of waste management which ends with sanitary landfills (SLFs). Unsanitary landfilling and open burning will represent the indiscriminate dumping and burning of MSW and represents the general situation of SWM in India and other developing countries.



Hierarchy of Sustainable Waste Management

The hierarchy of waste management recognizes that reducing the use of materials and reusing them to be the most environmental friendly. Source reduction begins with reducing the amount of waste generated and reusing materials to prevent them from entering the waste stream. Thus, waste is not generated until the end of "reuse" phase. Once the waste is generated, it needs to be collected. Material recovery from waste in the form of recycling and composting is recognized to be the most effective way of handling wastes. Due to technical and economic limitations of recycling; product design; inadequate source separation; and lack of sufficient markets that can use all sorted materials, most of the MSW generated in India ends up in landfills. Local authorities should start working with their partners to promote source separation. While this is being achieved and recycling is increased, provisions should be made to handle the non-recyclable wastes that are and will be generated in the future. A sustainable solution to handle non-recyclable waste is energy recovery. Energy recovery from wastes falls below material recovery. Land filling of MSW is equivalent to burying natural resources which could be used as secondary raw materials or as sources of energy. However, in the present society, landfills are required as a small fraction of wastes will have to be land filled. However, unsanitary land filling or open dumping of wastes is not considered as an option to handle MSW and is not at all recommended.

Municipal Solid Waste (Management & Handling) Rules, 2000

The salient aspects of the MSW (Management & Handling) Rules, 2000 are outlined below:

1. Prohibit littering on the streets, promote segregation of recyclable waste at source and ensure storage of waste at source in two bins; one for biodegradable waste and another for recyclable

waste.

2. Organize primary collection of biodegradable and non-biodegradable waste from the doorstep (including slums and squatter areas) at pre-informed timings on a day-to-day basis using containerized tricycle/handcarts/pick up vans.

3. Organize street sweeping covering all the residential and commercial areas on all the days of the year irrespective of Sundays and public holidays.

4. Abolish open waste storage depots and make provision of covered containers or closed body waste storage depots.

5. Organize transportation of waste in covered vehicles on a day to day basis avoiding multiple and manual handling of waste.

6. Set up treatment facilities for biodegradable waste using composting or waste to energy technologies meeting the standards laid down in schedule IV of the MSW Rules 2000.

7. Minimize the waste going to the land fill and dispose of only rejects from the treatment plants and inert material at the engineered landfills meeting the standards laid down in schedule III of the MSW Rules 2000.

Environment Policies

Several environment Policy statements have been formulated in the last few decades as a part of the Governments' approach to integrate environmental and developmental aspects of planning. The policies reflect a gradual shift in emphasis from pollution abatement and control to proactive and voluntary approaches for pollution prevention in keeping with global paradigm shifts and trends in environment management.

Following are some of the key policies that have been laid down by the Central Government:

National Forest Policy, 1988;

National Conservation Strategy and Policy Statement on Environment and Development, 1992;
Policy Statement on Abatement of Pollution, 1992.

Despite these policy documents, a need for a comprehensive policy statement had been evident for some time in order to infuse a common approach to the various sectoral and cross-sectoral, approaches to environmental management. As a result, a National Environment Policy (NEP, 2006) has been drawn up as a response to our national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A (g), strengthened by judicial interpretation of Article 21.

Legal Provisions for Environment

The principal environmental regulatory agency in India is the Ministry of Environment and Forests (MoEF), New Delhi. MoEF formulates environmental policies and accords environmental clearance for the projects.

It is important to note that the Central Government framed 'umbrella legislation', called the Environment (Protection) Act, 1986 to broadly encompass and regulate an array of environmental issues. The overall purpose of EPA is to establish an overall coherent policy and provide a basis for the coordinated work of various government agencies with operational responsibility for the environment and natural resources. This legislation also invests authorities with regulatory powers to address specific issues affecting the environment. The Act does not allow any person to establish an industry, operation or process that discharge or emit any environmental pollutant in excess of standards prescribed under specific rules and notifications.

Regulatory Framework

Law requires that every project proponent must take Environmental Clearance from Ministry of Environment and Forests, New Delhi, before starting up any project. The environmental clearance is also mandatory for the expansion, modernization or renewal projects. The conditions are applicable as per the MoEF guidelines and EIA notifications issued and amended time to time.

To keep the environment congenial for better standard of living, provisions have been made in the constitution of India and many enactments have taken place, so that, industrialization may not have adverse impact on the environment.

There are many Acts / Rules / Notifications issued by MoEF, New Delhi of which, few are mentioned in below table 1.13:

Table 1.13: Regulatory Frameworks

Water Pollution:		
1	1974	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988
2	1975	The Water (Prevention and Control of Pollution) Rules, 1975
3	1977	The Water (Prevention and Control of Pollution) Cess Act, 1977, amended 1992 ,amended 2003
4	1978	The Water (Prevention and Control of Pollution) Cess Rules, 1978
Air Pollution:		
5	1981	The Air (Prevention and Control of Pollution) Act 1981, Amended 1987
6	1982	The Air (Prevention and Control of Pollution) Rules, 1982
Environment Protection:		
7	1986	The Environment (Protection) Act, 1986, Amended 1991
8	1986	The Environment (Protection) Rules, 1986,(amended 2006)
9	1992	Environmental (Protection) Rules-"Environmental Statement"
10	1993	Environmental (Protection) Rules-"Environmental Standards"

11	1994	Environmental (Protection) Rules-"Environmental Clearance"
12	1996	The Environment (Protection) Second Amendment Rules-"Environmental Standards"
13	1997	Amendments in the Environment (Protection) Rules, 1994 "Public Hearing"
14	1998	Environment (Protection) Second Amendment Rules -"Environmental Standards"
15	1999	Notification for Use of Fly Ash (For 12 MW Thermal Power Plant)
16	2004	The Environment (Protection) Second Amendment Rules, 2004
17	2006	Notification for amendment in Environment clearance Rule
18	2006	The Environment Impact Assessment Notification 2006, as amended in 2009 & 2011
19	2009	Amendments in EIA notification, 2006
20	2011	Amendment in EIA notification, 2006 & 2009
Hazardous Substances Management:		
21	1989	The Manufacture, Storage and import of Hazardous Chemical Rules, 1989
22	1989	The Hazardous Wastes (Management and Handling) Rules, 1989
23	1996	The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996
24	1998	The Bio-Medical Waste (Management and Handling) Rules, 1998
25	2000	The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000
26	2000	The Hazardous Wastes (Management and Handling) Amendment Rules, 2000
27	2001	The Batteries (Management and Handling) Rules, 2001
28	2003	Hazardous Wastes (Management and Handling) Amendment Rules, 2003
29	2003	Bio-Medical Waste (Management and Handling) (Amendment) Rules, 2003
30	2008	The Hazardous Waste (Management, Handling and transboundary Movement) Rules, 2008 (in suppression of the hazardous Waste (management & Handling) Rules, 1989)

Noise Pollution :		
31	2000	Noise Pollution (Regulation and Control) Rules, 2000
32	2002	The Noise Pollution (Regulation and Control) (Amendment) Rules, 2002
33	2003	The Environment (Protection) Amendment Rules, 2003
Ozone Layer Depletion :		
34	2000	The Ozone Depleting Substances (Regulation and Control) Rules, 2000
Public Liability Insurance :		
35	1992	The Public Liability Insurance Act, 1991, amended 1992
36	1993	The Public Liability Insurance Rules, 1991, amended 1993
Petroleum Act/ Rules:		
37	1934	The Petroleum Act (as amended till 1997)
38	1976	The Petroleum Rules (as amended till 1995)
39	1981	Gas Cylinder Rules 2004 (replaces the Gas cylinder Rules, 1981),
40	1983	The Explosive Rules, 1983 (amended 2002)
41	1884	The Explosive Act, 1884 (amended 1983)
Factory Act/ Rules:		
42	1923	Indian Boiler Act 1923, amended 1986
43	1948 / 1952	The Factories Act (As amended till 2001)
44	1950	The Indian Boiler Regulations 1950 (amended 2007)
45	1956	The Indian Electricity Rules, 1956 (amended 2002)
46	1976	The Standards of Weights & Measures Act 1976
47	1977	The Standards of Weights & Measures (Packaged Commodities) Rules,1977
48	1981 / 2002	The Static & Mobile Pressure vessels (Unfired) rules, including amendment rules
49	1985	The Standards of Weights & Measures (Enf) Act 1985

50	1987	The Standards of Weights & Measures (General) Rules, 1987
51	1988	The Motor Vehicle Act 1988 (amended 2001)
52	1989	The Central Motor Vehicle Rules 1989 (amended 2006)
53	1996	Building & other construction Act, 1996
54	1910/ 2003	Indian Electricity Act 2003 (replaces The Indian Electricity Act, 1910
55	2000	The Chemical Weapons Convention Act, 2000
56	2001	Energy conservation Act, 2001
57	2008	Reach (An EU Law for import of Chemicals)

Conclusion

Solid waste management can be defined as the scientifically based control of solid waste generation, storage, collection, transfer and transport, processing, and disposal. This includes the technological, financial, institutional, and legal aspects of dealing with the full range of solid waste issues. Waste management practises vary between developed and developing countries, between urban and rural areas, and between residential and industrial producers. Producers accept their responsibility when designing their products to minimise life-cycle environmental impacts, and when accepting legal, physical or socio-economic responsibility for environmental impacts that cannot be eliminated by design.

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