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A Study of Solid Waste Management in India: Recent Scenario Composition, Disposal, Recycling

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ABSTRACT

Industrialization becomes very significant for developing countries like India having large number of population. Rapidly increased development and income per capita lead to high municipal solid waste production rates. In recent years, the use of electronic and other items also contributes significantly to the total waste stream. Such waste will pose a potential risk to human health or the environment if no part of managing solid waste is effectively managed. Solid waste management approach in India remains unscientific. The efficiency of solid waste collection in India is about 70%, while in the developed countries it is nearly 100%. The disposal of waste in many developed and developing countries is a rough and widespread problem in both urban and rural areas. Collection and disposal of municipal solid waste (MSW) is one of the major urban environmental problems today in most countries of the world. Solutions to the management of MSW must be sustainable financially, technically viable, socially, legally and environmentally-friendly. The biggest challenge for authorities in small and large cities is solid waste management. Solid waste management. Evaluating organic food waste is one of the key current areas of research. Conventional waste disposal, incineration, and composting are widely used as advanced waste disposal technologies. Today too, a large proportion of the solid wastes are discarded without prior treatment on the outskirts of towns or cities. That leads to contamination of groundwater and an increase in air pollution caused by percolation of leachate and gas release respectively. Different studies show that 80 percent of total solid waste is recyclable or reusable again. The incorrect segregation of waste and additional factors lead to outdated technology in recycling industries. But the recycling of plastic and paper has increased in particular because the consumption of both commodities continually increases. The current status of the municipal waste management in various regions of India is described in this study. It summarizes a collective, systematic effort to improve the implementation and awareness of the Integrated SWM system by implementing legal framework, institutional arrangements, financial provisions, technology, operational management, developing human resources and public participation.

1. Introduction

India is the world's second-largest population after China with a population of more than 1.27 billion and 17.6 percent (Official Population clock). Instead, India only shares 5 percent of the 3,185,263 square kilometers in the world. 68% are in rural areas, of the total population, and 32% are in urban areas. Since recent decades, urban population has been growing daily. Industry becomes an important part of modern society. Developing countries like India, which are also contributing to urbanisation, are at the industrialization level. Many people migrate for better opportunities into the city area. As regards GDP, India is with 7.30 percent GDP one of the world's fastest growing economies. By 2030 India is expected to grow by 10 percent of GDP. Increased GDP would contribute to a better standard of living. Rapid industrialization, over-population. Uncontrolled urban growth and improved living conditions result in an increased rate of waste generation per capita. Today, a mix of household activities and other commercial and institutional activities generate 1 27.486 tons of municipal solid waste per day. Comparably relevant environmental effects affect urban waste and other industrial waste. A large quantity of such waste is highly harmful for living things, including humans. It can decrease the quality of groundwater by percolating leachate, and can pollute the air through various treatment procedures by emitting greenhouse gazes. Electronic and nuclear waste is now another waste stream that is in need of attention because of the fastest growing nuclear and electronic industry.

The major problem for both large and small cities in developing countries is the solid waste management issue. Solid waste management. The main reason is that such solid waste is increasingly produced and the municipal budget is burdening. In addition to the high cost, a lack of understanding of different factor affecting the entire handling system is correlated with solid waste management. Literature analysis and reports on waste management in developing countries revealed that few articles provided quantitative information. The aim of these studies was to determine the actions / behavior of stakeholders which play their part in the management of solid waste and to analyze various factors which influence the system. Studies in 4 continents, 22 developing countries and over 30 urban areas were conducted. In order to inspire the participants and to determine the factors affecting the efficiency of solid waste management in the sample, a mixture of variable methods was discussed during this research. The rates and quantities of solid municipal waste generations have been

considerably accelerated by population growth, rapid urbanisation, a booming economy and a rise in standard of living for developing countries.

In India there was initially little understanding of the management and hierarchy of solid waste. The scenario of solid waste management has changed steadily, however, since recent years. However, effective solid waste management practices are still far-reaching. Even today, a proper treatment disposes only few solid waste created. Failure to isolate waste is the biggest barrier to effective management of solid waste. However, due to the high consumer demand of these items, the plastics and paper recycling industry is increasing. Incorrect collection, insufficient transport in some regions, lack of advances in treatment technologies, financial deficits in local governments are other reasons for poor solid waste management practices. It is important to note that the risks associated with different waste sources differ and that economic benefits can be gained by grouping of waste according to their risk level. In this report, an overview of the current status and problems of municipal solid waste management of the MSW of India has been given. In this review. Future trends in making MSW effective are summarized here. However, where possible it will cover brief discussion of other waste.

Sources, composition and characterization of the solid waste

One of the environmental challenges is municipal solid waste (MSW). MSW. Municipalities; in general, waste management is responsible. They must provide the inhabitants with an efficient and effective system. Nevertheless, sometimes they face other difficulties beyond the local authorities' capacity to deal with MSW [3]. This is mainly because of financial resources , organizational shortages and complexity[4]. The composition of MSW varies considerably between municipalities and between countries. Such variations are primarily dependent on the way of life, the economic situation, waste and industrial structure regulations. For determining the appropriate treatment and management of such waste, the amount and composition of the municipal solid waste are critical. Such information is essential and useful for the municipality's solid waste conversion plant. Based on MSW's calorific value, engineers and scientists will agree on the usefulness of the fuel. In the meantime, such information helps to predict gaseous emission composition. This MSW is subsequently exposed to technology for energy conversions including gasification, incineration, etc. However, it is necessary to look at the potential hazardous substances in the ash carefully [5]. The composition of waste will provide valuable information on the usefulness of the material for the production of compost or biogas as a fuel, either through biological conversion[6]. In the mean time, the composition of the MSW is greatly influenced. The time-based biodegradation of these MSW is an important factor regulating, in particular, the amount of recyclable material. The EPA estimates MSW in 2013 to be 254 million tons in the United States[7]. The structure and classification of such MSW material are given in figure. 1.

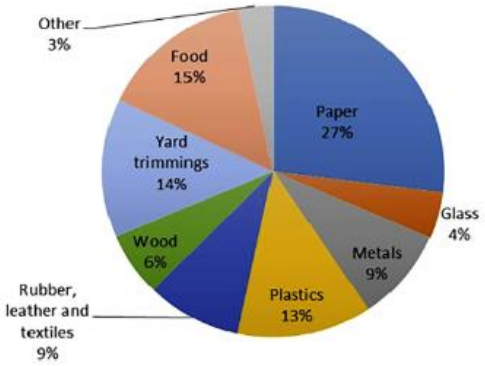

Fig. 1. Composition and classification (by material) of MSW

2. Waste Characteristics

Solid waste can generally be defined as waste which is not carried by water; this was rejected for further use. The program covers waste from industry , mining, municipal and farming. It consists primarily of a large organic material, ash, fine soil, paper and plastic, glass and metals. However, the composition of solid waste varies according to various factors like temperature, standard of living, etc. On the basis of its source, table-1 classifies solid waste.

1. Type of Solid Waste

In several ways, solids can be categorized by their source, structure, step, treatment, etc. Table-1 offers a summary of the waste form by source. It covers residential, municipal, mining, farming, industrial, etc.

Table 1. Type of Industrial Waste

Source	Typical Waste Generators	Type of Solid Waste
Residential	Household activities	Food waste, paper, cardboard, plastics, wood, glass, metals, electronic items etc.
Industrial	Manufacturing units, power plants, process industries etc.	Housekeeping wastes, hazardous wastes, ashes, special wastes etc.
Commercial & Institutional	Hotels, restaurants, markets, office buildings, schools, hospitals, prisons etc.	Bio-medical waste, Food waste, glass, metals, plastic, paper, special wastes etc.
Construction and Demolition	New construction sites, demolition of existing structures, road repair etc.	Wood, steel, concrete, dust etc.
Municipal services	Street cleaning, landscaping, parks and other recreational areas, water and wastewater treatment plants	Tree trimmings, general wastes, sludge etc.

Agriculture	Crops, orchards, vineyards, dairies, farm etc.	Agricultural wastes, hazardous wastes such as pesticides
Mining	Open-cast mining, underground mining	Mainly inert materials such as ash

Further solid municipal waste can be classified as garbage and rubbish as putrescible solid waste. The waste may contain a number of materials that can be fuel (paper, plastic etc.) or non-fuel (glass and metal, etc.). Special waste is collected and managed separately such as building debris, street litter, abandoned cars and old devices. It is made up of organic matter (51%), recyclables (17.5%) and others (31%). It is worth noting that due to informal separation of recycling waste at source, actual composition may be different. Table-2 provides an estimate of the composition of MSW in various parts of India.

Table 2. Composition of MSW in India and Regional Variation

Region/City	MSW (TPD)	Compostables (%)	Recyclables (%)	Inerts (%)	Moisture (%)	C.V. (MJ/kg)	C.V. (kcal/kg)
Metros	51,402	50.89	16.28	32.82	46	6.4	1523
Other Cities	2,723	51.91	19.23	28.86	49	8.7	2084
North India	380	50.41	21.44	28.15	46	9.8	2341
East 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

2. Physical Characteristics of MSW

CPCB reported the physical characteristics of MSW in different cities of India, which is shown in Table – 3

Table 3. Physical Characteristics of MSW in Indian Cities

City	Paper	Textile	Leather	Plastic	Metal	Glass	Ash, Fine earth, others	Compostable matter
Ahmedabad	6.0	1		3			50	40
Banglore	8.0	5		6	3	6	27	45
Bhopal	10.0	5	2	2		1	35	45
Mumbai	10.0	3.6	0.2	2		0.2	44	40
Culcutta	10.0	3	1	8		3	35	40
Coimbatore	5	9		1			50	35
Delhi	6.6	4	0.6	1.5	2.5	1.2	51.5	31.78
Hyderabad	7	1.7		1.3			50	40
Indore	5	2		1			49	43
Jaipur	6	2		1		2	47	42
Kanpur	5	1	5	1.5			52.5	40
Kochi	4.9			1.1			36	58
Lucknow	4	2		4	1		49	40
Ludhiana	3	5		3			30	40

Madras	10	5	5	3			33	44
Madurai	5	1		3			46	45
Nagpur	4.5	7	1.9	1.25	0.35	1.2	53.4	30.40
Patna	4	5	2	6	1	2.0	35	45
Pune	5			5		10	15	55
Surat	4	5		3		3	45	40
Vadodara	4			7			49	40
Varanasi	3	4		10			35	48
Visakhapatnam	3	2		5		5	50	35
Average	**5.7**	**3.5**	**0.8**	**3.9**	**1.9**	**2.1**	**40.3**	**41.8**

3. Chemical Characteristics

MSW contain few chemicals of which care must be taken i.e. nitrogen, phosphorus, potassium etc. In August 1995, NEERI presented a strategy paper of SWM in India in which chemical characteristics of MSW were discussed according to population range.

Table 4. Chemical characteristics of MSW in India

Population Range	Nitrogen (total nitrogen)	Phosphorus (P_2O_5)	Potassium (K_2O)	C/N Ratio	C.V. kcal/kg
0.1-0.5	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	0.66	0.56	0.69	21.13	900.61
1.0-2.0	0.64	0.82	0.72	23.68	980.05
2.0-5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

3. Disposal Of Solid Waste

Inappropriate storage, storage, transfer and/or transportation processes have been reported to have a major effect on the characteristics of solid waste. In addition, the poor planning path, lack of data on the timing of collection, number of solid waste collection vehicles, bad roads and inadequate infrastructure can also affect solid waste characteristics. Sharholy et al. have researched and published on efficient ways and affordable waste management services. To organize and encourage the informal sector. Knowledge of authorities' treatment is one of the major factors affecting solid waste management. Tadesse et al. have analyzed the factors influencing the disposal of household waste. Their findings have shown that the availability of waste plants affects waste disposal choice considerably. They indicated that the inadequate supply and the long distance between waste containers increases the likelihood that waste will be dumped during the trip in open areas and on roadsides. In addition , the absence of legislation, properly equiped and constructed landfills all contribute towards limiting the safe disposal and disposal of solid waste, both Pokhrel and Viraraghavan noted.

Management and recycling of solid waste

Sheinberg et al .have reported that there are indications in relation to pricing on solid waste disposal that high rates of recovery are linked to tip fees on the disposal site. High landfill costs have a positive effect on solid waste recovery. This includes the beneficial reuse of industrial waste or the value chains. Gonzalez-Torre and Adenso-Diaz noted that financial, altruistic and regulatory forces are essential reasons for good recycling practices in some societies. The author also said that people who often go to disposal in containers of their general waste are more likely to recycle certain products at home. The number of fractions separating, sorting and collecting their solid waste in the home in most cases increases with the distance to the recycler. It was added by Minghua et al. that the local government should encourage recycling markets and increase the professional use of recyclable materials in order to increase recycling rates. Other scholars, including financial support for various recycling projects, have mentioned other important factors in order to support their country's recycling infrastructure. Other researchers proposed that they drop and purchase centres. Informal sector organization for solid waste recycling was suggested by Sharholy et al. Indeed, in most countries around the world today, collecting and depositing MSW is a major urban environmental problem. Solutions for the management of MSW must be financially viable, technologically feasible, social , legal and ecologically safe. Currently, European policy pushes for adapting multiple rational policies to natural resources. Today, waste recovery is a technologically promising prospect. It becomes a process that can be combined with recycling and the generation of waste to

energies through the sorting of the MSW at the source. Nevertheless, techniques such as the elimination or mechanical sorting of MSW in sites do not efficiently enhance the management of MSW. Deposits must therefore be the MSW's final disposal site. In many countries, however, conventional waste disposal sites are still being built. Hadjibiros et al. have indicated that site selection is extremely important because many social issues emerge because of a lack of public acceptability. Most of these countries have no proper control of their MSW. The result is pollution of air , soil and water. Waste management is therefore one of the main problems facing mankind today. Wastes should, however, be viewed not only as a source of materials (metals, glass, plastics and fibers) and energy recovery, but also as a savings tool and a tool to protect the environment. Considering the global energy derived from organic farming waste, including agricultural residues, the approximate oil equivalent is about 50 milliards tons. The UNEP notes that an adequate separation is necessary for effective energy production between organic and non-organic waste. In fact, organic residues undermine the efficiency of the thermal technology as regards the energy generated and the emissions of GHGs. The way this waste is processed is shown in the figure. 2.

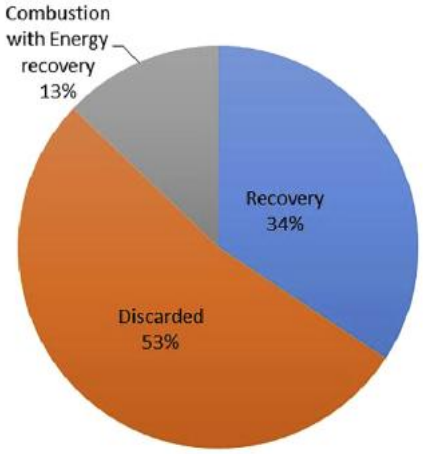

Fig. 2. Management of MSW

4. Waste Collection and Transportation

Until 1980, not much data on solid waste production and very little attention was paid to solid waste management. However, enforcing the Environmental Protection Act (1986) and the Hazardous Waste Management Laws (1989) has changed the mindset and local authorities and governments.

1. Methods of Collection

Under the Municipal Waste Management Rules (2000), municipalities are responsible for banning the littering of solid waste in towns, towns and metropolitan areas identified by governments. Municipal authorities have to organize house-to-home collection using any method to facilitate methods:

- Community bin collection
- House to house collection
- Collection on regular time interval (which must be pre-informed)
- Scheduling by using bell ringing of musical vehicle (without exceeding the noise levels)

The integration of these methods is necessary to increase collection efficiency. In general, container transporters carry out transport of municipal solid waste twice a week or week. However, dumper trucks are used for waste collection in small towns and rural areas. Recently, the efficiency of waste collection has greatly improved in only a few rural areas with the help of NGOs and local communities. As the cost of collection is 50-70 percent of the cost of solid waste, it is the main area in which costs are cut. At the planning stage, integrated criteria, e.g. job rate, crew size, union cap, collection frequency, disposal and output distance (travel time), and annual equipment costs must be considered.

2. Scenario of MSW Collection in India

In addition to certain NGOs experts in this solid waste management sector, many local authorities have taken initiatives for efficient waste collection. In metropolitan towns and other urban areas it has been shown that waste management is much greater than in rural areas. Initiatives to increase collective efficiency are taken by states such as Gujarat , Maharashtra, Andhra Pradesch, Delhi, Tripura, while countries such as Arunachal Pradesh, Nagaland still fail to comply with MSW Regulations 2000 and follow unscientific methods of collecting waste. Table – 5 displays the collection levels of the different Indian states.

Table 5. State wise Waste Collection Data(CPCB, 2012)

State	Quantity Generated (TPD)	Collected (TPD)
Andaman & Nicobar	50	43
Andhra Pradesh	11500	10655
Arunachal Pradesh	94	NA
Assam	1146	807
Bihar	1670	1670
Chandigarh	380	370
Chhattisgarh	1167	1069
Daman Diu & Dadra	28+13=41	NA
Delhi	7384	6796
Goa	193	NA
Gujarat	7379	6744
Haryana	537	NA
Himachal Pradesh	304	275
Jammu & Kashmir	1792	1322
Jharkhand	1710	869
Karnataka	6500	2100
Kerala	8338	1739
Lakshadweep	21	21
Madhya Pradesh	4500	2700
Maharashtra	19204	19204
Manipur	113	93
Meghalaya	285	238
Mizoram	4742	3122
Nagaland	188	140
Orissa	2239	1837
Puducherry	380	NA
Punjab	2794	NA
Rajasthan	5037	NA
Sikkim	40 (capital)	32
Tamil Nadu	12504	11626
Tripura	360	246
Uttar Pradesh	11585	10563
Uttrakhand	752	NA
West Bengal	12557	5054
34 States	**127486**	**89334**

Table 6. Collection Efficiency of Indian Cities

Name of the City	Collection Efficiency (%)	Name of the City	Collection Efficiency (%)
Bombay	96.6	Madurai	51.6
Madras	90	Pune	70
Banglore	68.1	Baroda	60
Coimbatore	64.6	Bhopal	93.5
Ahmedabad	90	Salem	19.2
Kanpur	70	Lucknow	83
Indore	83.3		

5. Conclusion

Despite the progress made in solid waste management in recent years, there is a need to speed up progress. Conduct referred to in rules relating to MSW shall be applied. It is time to promote technological entrepreneurship, so that solid waste management can be effective. NGOs should participate in different waste management components, including awareness of the public. There is considerable public involvement in solid waste management. Authorities must protect citizens' fundamental rights through best practices and people have basic tasks to carry out through their contribution to these practices. Solid waste is one of the major environmental challenges. Under-management of waste causes ecosystems to change, including air , water and soil pollution, and therefore poses a real threat to human health. Some studies have shown that local people near MSW have low birth weight, congenital anomalies and few types of cancer. The increase in solid waste generation placed a burden on the high municipal budget costs. Population growth, rapid urbanisation, booming economies and rising living standards have significantly accelerated municipal solid waste production rates, volume and quality. Biodegradation of MSW by time is a major factor governing especially the amount of organic content in the recyclable material. Highly heterogeneous in character are MSW produced from developing countries. Inadequate bin collection, collection, transfer and/or transport systems have a big impact on solid waste characteristics. The waste disposal of plastics is an important global environmental issue.

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