

SOLID WASTE MANAGEMENT IN INDIA

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ABSTRACT:

A solid waste management (SWM) system includes the generation of waste, storage, collection, transportation, processing and final disposal. India is the second largest nation in the world, with a population of 1.21 billion (census 2011), accounting for nearly 18 percent of world's human population, but it does not have enough resources or adequate system in place to treat its solid wastes. Its urban population grew at a rate of 31.8 percent during the last decade to 377 million, which is greater than the entire population of US. India is facing a sharp contrast between its increasing urban population and available services and resources. Solid waste management is one such service where India has an enormous gap to fill. Proper municipal solid waste (MSW) disposal system to address increasing amount of waste is absent. Improper solid waste management deteriorates public health, causes environmental pollution, accelerates natural resources degradation, causes climate change and greatly impacts the quality of life of citizens. Therefore, in this research work an attempt has been made to analyze the Municipal Solid Waste (MSW) generation rates in different urban centers in India and also to study the effect of economic growth and changing lifestyle on composition and generation of MSW in India. This research work is mainly descriptive in nature and simple statistical tools have been used.

Key Words: Solid Waste Management, environmental pollution, economic growth

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1. INTRODUCTION:

Waste is an unavoidable by product of human activities. Any unwanted or discarded material thrown away in solid form through community activity is solid waste. Solid waste management is one of the major environmental problems of both developed and less developed nations. Rapid industrialization and population explosion in India has led to the migration of people from villages to the cities, which generate thousands of tons of MSW (Municipal Solid Waste). With increasing urbanization and changing life styles, Indian cities now generate eight times more MSW than they did in 1947.

The present citizens of India are living in times of unprecedented economic growth, rising aspirations and rapidly changing lifestyles, which will raise the expectations on public health and quality of life. The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011, fuelled by changing lifestyles and increased purchasing power of urban Indians. Urban population growth and increase in per capita waste generation have resulted in a 50 percent increase in the waste generated by Indian cities within only a decade since 2001. There are 53 cities in India with a million plus population, which together generate 86,000 TDP (31.5 million tons per day) of MSW at a per capita waste generation rate of 500 grams/day. The total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW. Such a steep increase in waste generation within a decade has served the stress on all available natural, infrastructural and budgetary resources.

Big cities collect about 70-90 percent of MSW generated; whereas smaller cities and towns collect less than 50 percent of waste generated. More than 91 percent of the MSW collected formally is landfilled on open lands and dumps. It is estimated that about 2 percent of the uncollected wastes are burnt openly on the streets. About 10 percent of the collected MSW is openly burnt or is caught in landfill fires.

2. REVIEW OF LITERATURE:

Michael Yhdego (1994), he said urban solid waste in Tanzania is a serious environmental problem. Concurrent with recent socio economic development, coupled with liberalization of the economy and rapid population growth, the quantum of solid waste generated has increased at a

rapid rate. A conceptual framework based on application of sustainability to waste prevention, utilization and recycling for urban solid waste management is proposed. The paper suggests several solid waste management challenges based on issues and principle analyzed and discussed.

Gupta and Mohan et al. (1998), has defined in India the collection, transportation and disposal of MSW are unscientific. Uncontrolled dumping of wastes on outskirts of towns and cities has created overflowing landfills, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. They revealed that the country also needs something in terms of policy and guidelines to enable the multiple corporations to run the waste services efficiently.

Madhushree Sekher (2004), analyzed the process of municipal waste management in the city of Bangalore. The paper considered the characteristics of municipal waste generated, the management practices involved and the role of stakeholders in the overall process. Inadequate municipal service, unscientific disposal system, lack of civic awareness in waste management, lack of proper market for recycled waste products etc were found as the most important deficiencies in the waste management system.

V Gawaiker (2006) he said the most important aspect of solid waste management is the quantity of waste to be managed. The quantity determines the size and number of functional units and equipments required for managing the wastes. The quantities are measured in terms of weight and volume. The weight is fairly constant for a given set of discarded objects where as volume is highly variable.

Dinesh Kumar Mittal, IAS (2008) has defined India, one of the fastest growing economies in the world, faces a challenge of MSW management. To address the issue, the Indian Govt. enacted MSW (Handling and Management) rules in the year 2000 with a view to improve the present scenario. All Urban Local Bodies (ULBs) were supposed to have MSW management by the end of the year 2003. This edition of the Newsletter focuses on the opportunities available in

the management of Municipal Solid Waste and the successful projectization of one such opportunity in the form of Timarpur-Okhla Integrated municipal processing facility in the state of Delhi.

Identifying the gap in literature, this paper tries to draw the relationship between population explosion and municipal waste generation. Population has a great effect on waste generation which impacts the environment and sustainability which includes space availability, landfill leachate, global warming, loss of habitat and consumption of natural resources (Franchetti, M.,2009). Apart from this, an attempt has also been made to show the effect of economic growth and changing lifestyle on composition and generation of MSW in India.

3. OBJECTIVES OF THE STUDY:

- To show the Municipal Solid Waste (MSW) generation rates in different urban centres in India.
- To study the effect of economic growth and changing lifestyle on composition and generation of MSW in India.
- To examine the impact of population growth on solid waste generation in India.

4. RESEARCH QUESTION:

- Whether the variables like population growth, per capita income, economic growth etc. has an impact on the composition and quantity of MSW in the country?

5. METHODOLOGY AND DATA SOURCE:

The research paper is analytical in nature entirely based on secondary data. The secondary data has been collected from various sources like journals, Census Report, NEERI Reports, Annual Reports of Central Pollution Control Board (CPCB), Report by Department of Economic Affairs (DEA), Comptroller and Auditor General's Report etc. in order to fulfill the objectives of the study. Simple statistical tools like table, graph, flow chart etc, have been used for analysis.

6. DISCUSSION AND ANALYSIS:

6.1. Municipal Solid Waste (MSW):

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).

Table 1: Sources and Types of Municipal Solid Waste

Residuals	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, glass, textiles, 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 sweeping, landscape and tree trimmings, general wastes from parks, beaches and other recreational areas

Source: Hoornweg (1999)

Waste is any material which is not needed by the owner, producer or processor. Any unwanted or discarded material thrown away in the solid form through community activity is solid waste. Depending upon the source, MSW is categorized into three types: Residential or household waste which arises from domestic areas from individual houses; commercial wastes and/or institutional wastes which arise from individually larger sources of MSW like hotels, office buildings, schools, etc.; municipal services wastes which arise from area sources like streets, parks, etc. MSW usually contains food wastes, paper, cardboard, plastics, textiles, glass, metals, wood, street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and

other recreational areas. Sometimes other household wastes like batteries and consumer electronics also get mixed up with MSW.

6.2. 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. Metros and other big cities in India collect between 70- 90% of MSW. Smaller cities and towns collect less than 50%.

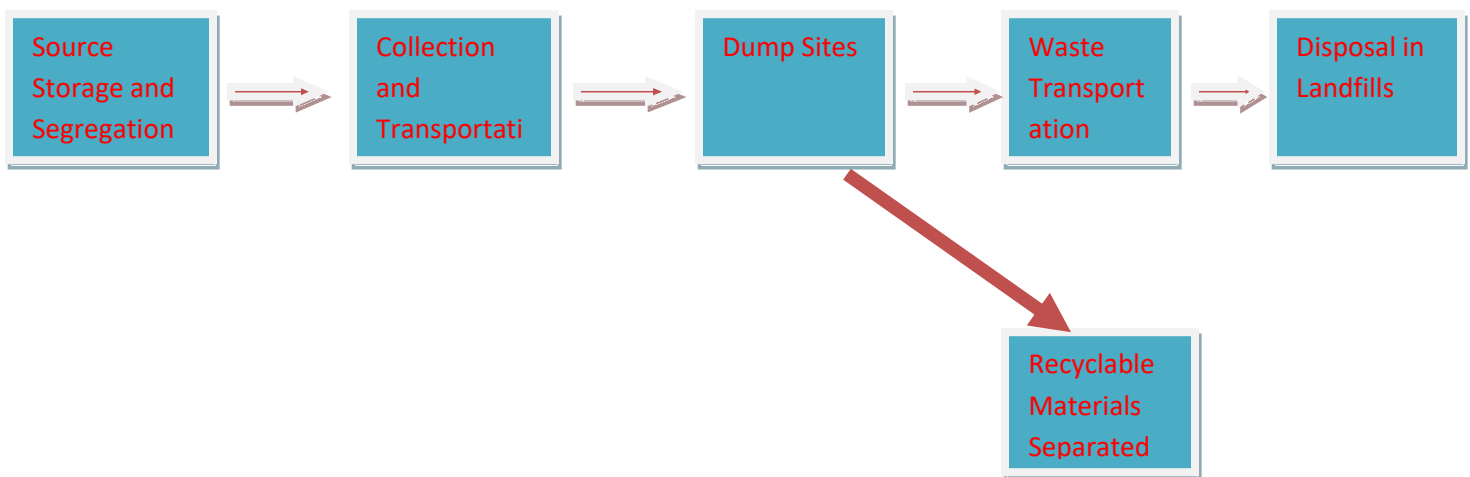
6.3. Solid Waste Management Sector in India:

Management of Municipal Solid Waste (MSW) continues to remain one of the most neglected areas of urban development in India. Magnitude and density of urban population in India is increasing rapidly and consequently the civic bodies are facing considerable difficulties in providing adequate services such as supply of water, electricity, roads, education and public sanitation, including Municipal Solid Waste Management (MSWM). Municipal agencies spend about 5-25% of their budget on MSWM. In spite of such a heavy expenditure, the present level of service in many urban areas is so low that there is a threat to public health in particular and to environmental quality in general. Several steps are being taken towards improving the situation. As per estimates, 115,000 tons of solid wastes are generated per day in the country. Yearly

increase is about 5% annually. Urban Local Bodies (ULBs) spend about Rs. 500 to Rs. 1,500 per ton on solid waste collection, transportation, treatment and disposal. However, hardly any amount is spent on scientific disposal of waste. It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0.1 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively. Studies carried out by National Environmental Engineering Research Institute (NEERI) indicated that the per capita generation rate increases with the size of the city and varies between 0.3 to 0.6 kg/day in the metropolitan areas, values up to 0.5 kg / capita / day have been recorded. The estimated annual increase in per capita waste quantity is about 1.33% per year.

MSW Collection to Disposal Value Chain

Source: EAI



The schematic sketch above illustrates the steps carried out in managing solid waste in India. According to India's constitution, Solid Waste Management (SWM) falls within the purview of the state government. The activities are entrusted to Urban Local Bodies through state legislations. In most of the Indian cities, the MSW collection, segregation, transportation, processing and disposal is carried out by the respective municipal corporations and the state governments enforce regulatory policies.

6.3.1.Private Sector Participation in SWM:

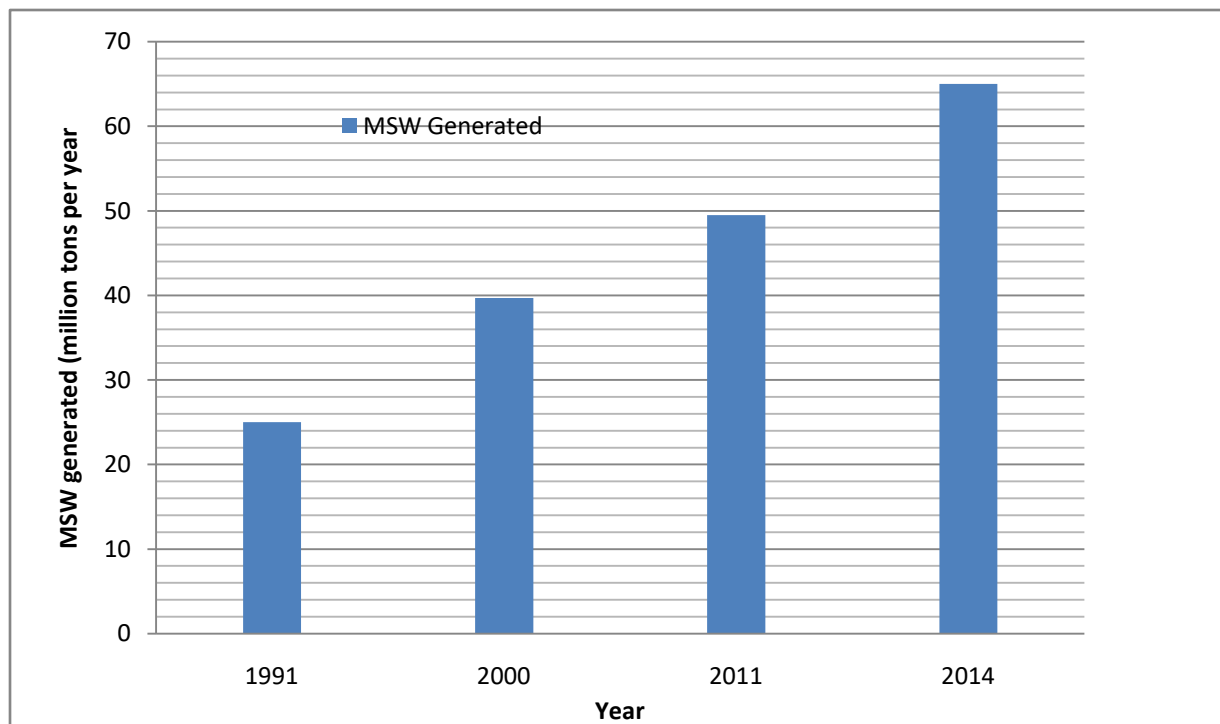
In some cities like Mumbai, Chennai, Delhi, Bangalore, Hyderabad, Ahmedabad etc., garbage disposal is done by Public Private Partnerships (PPPs). The private sector has been involved in door-to-door collection of solid waste, street sweeping in a limited way, secondary storage and transportation and for treatment and disposal of waste. Some private firms are carrying out Integrated Municipal Solid Waste Management (IMSWM) which includes collection, segregation & transportation, treatment, compost, biomethanation, refuse derived fuel, and final disposal. However, there are serious barriers to private sector participation in urban infrastructure as the financial status of ULBs except for a minority, is precarious. Urban sector is seen as a very high-risk sector and also because of institutional complexity due to multiplicity of agencies involved in service delivery. Further, there is lack of a regulatory or policy enabling framework for PPPs, barring few exceptions, and lack of bankable and financially sustainable projects considering the opportunities and risks involved. There is also a need to rationalize tariffs and user charges.

6.3.2.Existing Scenario of Solid Waste Generation Rates in India:

India is growing and so are the mountains of waste in cities and villages are producing. The composition of waste is also witnessing a major shift as the use of plastic and paper grow with the rise of middle class and a consumerist culture. The 2009 Comptroller and Auditor General's (CAG) Report on waste management estimated that urban India produced some 48 million tons of municipal solid waste (MSW) annually, calculated at 0.4 kg per capita per day. In the same year, the Department of Economic Affairs (DEA) estimated that about 58 million tons of waste was generated per year. The 2012 Central Pollution Control Board (CPCB) status report on MSW put this number at 47 million tons for 2011-2012. The 2014 Report of Planning Commission Committee chaired by K. Kasturirangan found that 62 million tons of MSW was produced per year which is based on an average of 0.45 kg per capita per day for India's urban population. According to a latest CPCB Report in 2016, India produced some 52 million tons of waste each year, or roughly 0.144 million tons per day, of which roughly 23 percent is processed- taken to landfills or disposed of using other technologies.

The issue with the data on waste generation in India is that all the figures are extrapolated values taken from the report produced by CPCB with the assistance of Nagpur-based National Environmental Engineering Research Institute (NEERI) in 2004–05 in 59 cities (35 metro cities and 24 state capitals). This was the last report having real time data and estimates on waste generation in the country. Since then, data on generation of solid waste is calculated by multiplying the urban population by the amount of waste generated per capita per day. This makes estimates of solid waste generated in the country pretty much a guesstimate which, in turn, confounds management. However, what the estimates do demonstrate is the fact that bigger and richer cities produce more waste than poorer cities.

Graph 1: Solid Waste Generation in India (1991-2011)



Source : Compiled from research papers and available documents (DEA and CPCB)

As per a 2008 joint paper by NEERI and CPCB on the assessment of the status of MSW management in metro cities, state capitals, Class I cities, and Class II towns in India, (examining over 59 cities across India), the per capita generation in India lies between 0.2–0.6 kg per capita per day. Cities with a population of less than 0.1 million have a per capita waste generation of about 0.17–0.5 kg; however, cities with over 2 million population, mainly the metros and Class I cities such as Delhi, have a per capita waste generation in the range of 0.22–0.62 kg. The paper

offers differences in standard of living, food habits, geographical status, employment of workers per 1,000 population, road conditions, difference in implements, equipment and machinery used, and climatic conditions, which all vary from city to city, as possible reasons for the staggered data.

As per a 2009 report of the Department of Economic Affairs, per capita waste generation is increasing by about 1.3 per cent annually. Given that urban population is growing at an annual rate of 3–3.5 per cent, the yearly increase in the overall quantity of solid waste comes to about 5 per cent.

A 2012 study by Columbia University on solid waste management in India analyzed the per capita waste generation in the context of the growth in the population of India. The study also did per capita MSW estimations, extrapolated till 2041 when it would be around 0.74 kg per person per day.

S. No.	States	Municipal Solid Waste (TPD) 2000	Municipal Solid Waste (TPD) 2009 - 2011	Collected (in %) 2009 - 2011	Treat ed (in %) 2009 – 2011)
1	Andhra Pradesh	4376	11500	92.65	34.31
2	Assam	285	1146	70.41	9.04
3	Delhi	4000	7384	92.03	28.35
4	Gujarat	NA	7379	91.38	12.94
5	Karnataka	3278	6500	32.30	100
6	Kerala	1298	8338	20.85	12.3
7	Madhya Pradesh	2684	4500	60.0	36.11
8	Maharashtra	9099	19204	100	10.83
9	Manipur	40	113	82.30	3.22

10	Meghalaya	35	285	83.50	42.01
11	Orissa	655	2239	82.04	1.79
12	Tamil Nadu	5403	12504	92.97	5.8
13	Tripura	33	360	68.33	16.26
14	Uttar Pradesh	5960	11585	91.17	NA
15	West Bengal	4621	12557	40.24	12.01

Table 2: Statistics of MSW Generated, Collected AND Treated in different States of India

Source: CPCB (2000B, 2013)

In India, Rapid urbanization and uncontrolled growth rate of population are the main reason for MSW to become an acute problem. It is anticipated that population of India would be about 1,823 million by 2051 and about 300 million tons per annum of MSW will be generated that will require 1,450km square of land to dispose it in a systematic manner, if ULBs of India continue to rely on landfill route for MSW management (position paper on the solid waste management sector in India, 2009).

6.4. Effect of Economic Growth and changing Lifestyle on composition of MSW:

The waste generation rate generally increases with increase in GDP during the initial stages of economic development of a country, because increase in GDP increases the purchasing power of a country which in turn causes changes in lifestyle. Even a slight increase in income in urban areas of developing countries can cause a few changes in lifestyle, food habits and living standards and at the same time changes in consumption pattern. Therefore, high income countries generate more waste per person compared to low income countries due to the difference in lifestyles.

Since economic reforms in 1992 – 1993, India has undergone rapid urbanization, which changed material consumption patterns, and increased the per capita waste generation rate. Since 2011, India underwent unprecedented economic growth and the urban per capita waste generation increased from 440 grams/day to 500 grams/day at a decadal per capita waste generation growth rate of 13.6%.

The change in lifestyles has caused considerable change in the composition of MSW generated in India too. Following a trend expected during the economic growth of a country, the percentage of plastics, paper and metal discarded into the waste stream increased significantly and the amount of inerts in the collected waste stream decreased likewise due to changes in collection wastes generated due to lifestyle changes, and b) decrease in the overall percentage of inerts due to improvement in collection.

Table 3: Change in Composition of municipal solid waste in India (1996 – 2011) (in %)

Year	Biodegradables	Paper	Plastic	Metal	Glass	Inert
1996	42.21	3.63	0.60	0.49	0.60	45.13
2005	47.43	8.13	9.22	0.50	1.10	25.16
2011	42.51	9.63	10.11	0.63	0.96	17.00

Source: Planning Commission Report

6.5. Impact of Population growth on Solid Waste Generation in India:

6.5.1. Population:

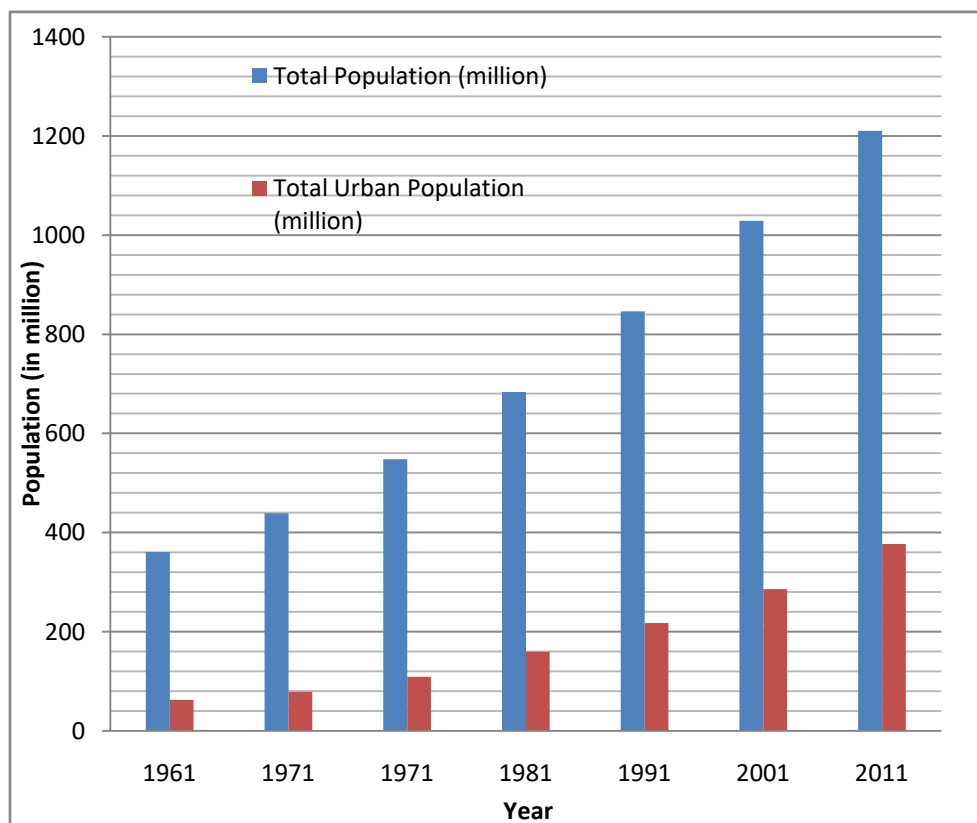
India is the second most populous nation on the planet. The Census of 2011 estimates a population of 1.21 billion which is 17.66% of the world population. It is as much as the combined population of USA, Indonesia, Brazil, Pakistan, Bangladesh and Japan. The population of Uttar Pradesh is greater than that of Brazil, the fifth most populous nation in the world. India's urban population was 286 million in 2001 and increased by 31.8% to 377 million in 2011. Indian urban population is greater than the total population of USA (308.7 million), the third most populous nation. The 366 cities of India which represent 70% of its total urban population generate 130,000 TPD or 47.2 million TPY at a per capita waste generation rate of 500 grams/day. This implies the total MSW generated by urban India could be as much as 188,500 TPD or 68.8 million TPY. This number matches the projection (65 million TPY in 2010) by Sunil Kumar, et al. Therefore, this report assumes that the quantum of waste generated by urban India to be 68.8 million TPY. The general consensus on amount of waste generated by urban India is 50 million TPY, which is a very low in comparison to the current findings. The six metro cities, Kolkata, Mumbai, Delhi, Chennai, Hyderabad and Bangalore together generate 48,000 TPD (17.5 million TPY) of MSW. Currently, India has 53 cities with population greater than one million, generating 86,245 TPD (31.5 million TPY), which is about 46 % of the total

MSW generated in urban India. The remaining 313 cities generate 15.7 million TPY (43,000 TPD), 23% of the total urban MSW, only half of that generated by the 53 cities with million plus population.

6.5.2. Population Growth:

Indian population increased by more than 181 million during 2001 – 2011, a 17.64% increase in population, since 2001. Even though this was the sharpest decline in population growth rate registered post-Independence the absolute addition during 2001-2011 is almost as much as the population of Brazil, the fifth most populous country in the world. It is clear that the scale of populations dealt with in case of India and China are entirely different from any other country in the world. The third most populous nation after China and India is US, with a population of 308.7 million, which is only a quarter of India's population. Urban population in India alone, which is 377 million, exceeds this figure. Indian urban population increased by 31.8 % during 2001 – 2011, which implies an annual growth rate of 2.8% during this period

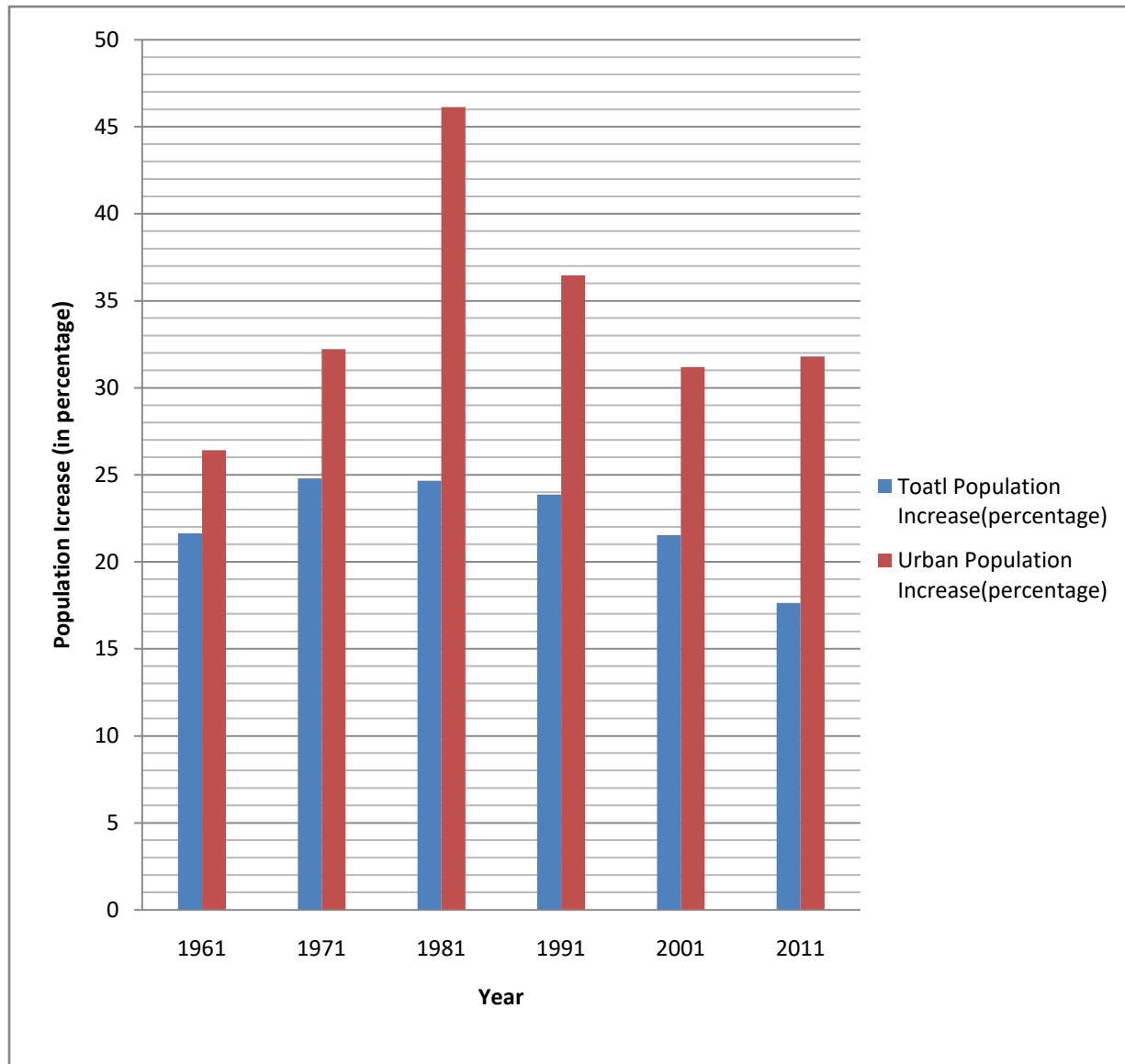
Graph2: Total Population and Urban Population Growth



Source: Sustainable Solid Waste Management in India, 2012

Urban population growth in India has always been higher than the overall population growth as can be seen in *Graph 2*, implying a trend of urbanization. Compared to the steady decrease in the percentage of urbanization during 1981 – 2001, the value stabilized during the past two decades, 1991 – 2011 (*Graph 3*). The urban population growth in the past decade increased the quantum of wastes generated by urban India by 50%.

Graph 3: Trend of Urbanization in India



Source: Sustainable Solid Waste Management in India, 2012

6.5.3. Impact on MSW Generation and Disposal:

Population growth and rapid urbanization means bigger and denser cities and increased MSW generation in each city. The data compiled for this paper indicate that 366 cities in India were generating 31.6 million tons of waste in 2001 and are currently generating 47.3 million tons, a 50% increase in one decade. It is estimated that these 366 cities will generate 161 million tons of MSW in 2041, a five-fold increase in four decades. At this rate the total urban MSW generated in 2041 would be 230 million TPY (630,000 TPD).

Table 4: Population Growth and Impact on Overall Urban Waste Generation and Future Prediction until 2041.

Year	Population (million)	Per Capita Waste Generation Thousand Tons /year	Total Waste Generation Million Tons / year
2001	197.3	0.439	31.63
2011	260.1	0.498	47.30
2021	342.8	0.569	71.15
2031	451.8	0.649	107.15
2036	518.6	0.693	131.24
2041	595.4	0.741	160.96

Source: Population Projections from scenario B, Population forecast of India, 1997

MSW Rules 2000 mandate “landfills should always be located away from habitation clusters and other places of social, economic or environmental importance”, which implies lands outside the city. Therefore, increase in MSW will have significant impacts in terms of the land which is required for disposing the waste as it gets more difficult to site landfills. However, farther the landfill gets from the point of waste generation (city), greater will be the waste transportation cost.

Table 5: Area of Land Occupied / Required for Unsanitary Disposal of MSW

Year	Area of Land Occupied/ Required for MSW Disposal (sq. km)	City Equivalents
1947-2001	240	50 % of Mumbai
1947-2011	380	90% of Chennai

1947-2021	590	Hyderabad
2009-2047	1400	Hyderabad+Mumbai+Chennai

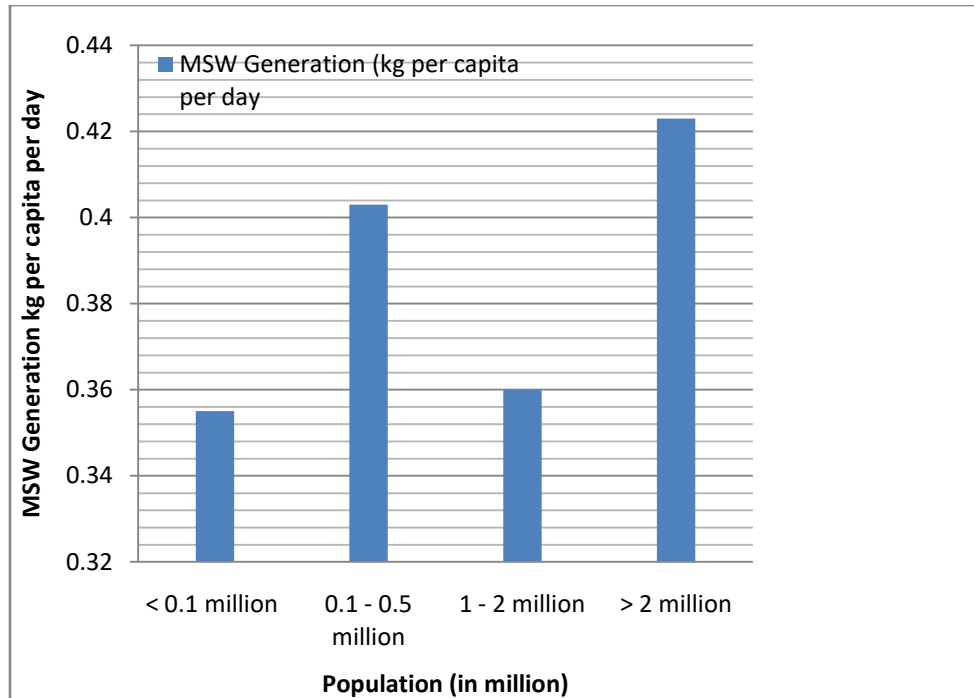
Source: TERI Report, 1998

A 1998 study by TERI (The Energy Resources Institute, earlier Tata Energy Research Institute) titled ‘Solid Waste Management in India: options and opportunities’ calculated the amount of land that was occupied by waste disposed post independence, until 1997. The study compared the land occupied in multiples of the size of a football field and arrived at 71,000 football fields of solid waste, stacked 9 meters high. Based on a business as usual (BAU) scenario of 91% landfilling, the study estimates that the waste generated by 2001 would have occupied 240 sq.km or an area half the size of Mumbai; waste generated by 2011 would have occupied 380 sq.km or about 220,000 football fields or 90% of Chennai, the fourth biggest Indian city areawise; waste generated by 2021 would need 590 sq.km which is greater than the area of Hyderabad (583 sq.km), the largest Indian city, area-wise (18) (19). The Position Paper on The Solid Waste Management Sector in India, published by Ministry of Finance in 2009, estimates a requirement of more than 1400 sq.km of land for solid waste disposal by the end of 2047 if MSW is not properly handled and is equal to the area of Hyderabad, Mumbai and Chennai together.

6.5.4.Per Capita Waste Generation in Indian Cities:

The quantity and characteristics of waste generated in an urban area depends generally on the size of its population, area, level of economic activities and the culture of the residents (K. N. Nair et al. 2004) . per capita waste generation ranges between 0.2 kg and 0.6 kg per day in the Indian cities which will work out to about 1.15 lakh MT of waste per day and 42 million MT annually. The average per capita waste generation will increase as the city expands (Asnani, 2006). The Table 2 show the relationship between waste generation per capita and population range in Indian cities. The average density of Indian MSW at the point of collection varies from 400 to 600 kg/ m³.

Graph 4: Per Capita Waste Generation –NEERI – CPCB (2008)



Source: Sunil Kumar et al. 2008, “Assessment of the Status of Municipal Solid Waste Management in metro cities, state capitals, class I cities, and class II towns in India: An Insight”, *Elsevier, Waste Management* 29 (2009) pp 883- 895.

7. Conclusion:

From the above analysis, it can be concluded that with the increase in population and urbanization, the quantity of MSW is increasing at a faster rate and also the composition is changing. Hence, necessary action should be taken so as to reduce the waste either by disposing it or recycling periodically. The changing pattern of waste composition emphasizes the importance of segregation for successful operation of waste management facilities. The other way is to conduct awareness programme for the people regarding the waste generation and its effect on human health and sustainability.

8. Limitations of the Study:

The study has the following limitations.

Statistics relating to MSW are scattered and inadequate. Municipalities don't keep adequate data and quantifiable treatment of the environmental issues is hardly possible.

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