Municipal Solid Waste Management in India-Current State and Future Challenges: A Review

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Abstract

Estimation on the quantity and characteristics of municipal solid waste and its forecasting over the planning period is the key to a successful management plan. This study analyses the changing trend in the MSW quantities and characteristics in major urban agglomerations in India over last four decades. The study critically reviews the present practices of estimating and forecasting of MSW and highlights their limitations. The changing need for the appropriate waste management technologies with respect to the changing pattern of the waste generation is also highlighted, which can help the urban local bodies responsible for MSW management in preparing more efficient plans.

Key Words: Municipal solid waste; Projections; Paper; Plastic.

1. Introduction

Due to population growth, industrialization, urbanization and economic growth, a trend of significant increase in municipal solid waste (MSW) generation has been recorded worldwide. MSW generation, in terms of kg/capita/day, has shown a positive correlation with economic development at world scale. Due to rapid industrial growth and migration of people from villages to cities, the urban population is increasing rapidly. Waste generation has been observed to increase annually in proportion to the rise in population and urbanization. The per capita generation of MSW has also increased tremendously with improved life style and social status of the populations in urban centres [1]. As more land is needed for the ultimate disposal of these solid wastes, issues related to disposal have become highly challenging [2].

India, with a population of over 1.21 billion account for 17.5% of the world population (Census of India 2011). According to the provisional figures of Census of India 2011, 377 million people live in the urban areas of the country. This is 31.16 % of the Country's total population. Figure 1 illustrates that the growth of urban population is at a much faster rate than the growth of rural population. India has 475 Urban Agglomerations (UA), three of which has population over 10 million. Table 1 gives the top five UAs in terms of population. The very high rate of urbanisation coupled with improper planning and poor financial condition has made MSW management in Indian cities a herculean task.

Table-1

Cities	Population
Greater Mumbai UA	18.4 Millions
Delhi UA	16.3 Millions
Kolkata UA	14.1 Millions
Chennai UA	8.7 Millions
Bangalore UA	8.5 Millions

Source: censusindia.gov.in/2011-Documents/UAs-Cities-Rv.ppt

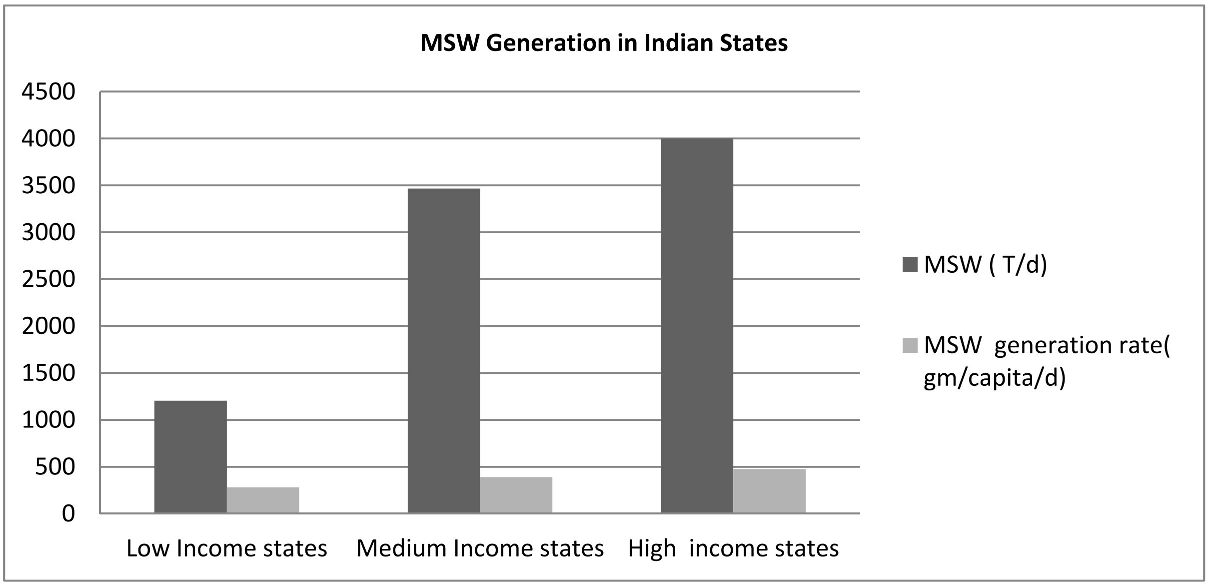


Figure 4

3. Characteristics and composition of MSW

As compare to the western countries, MSW differs greatly with regard to the composition and hazardous nature, in India [31-33].Many categories of MSW are found such as food waste, rubbish, commercial waste, institutional waste, street sweeping waste, industrial waste, construction and demolition waste, and sanitation waste. MSW contains compostable organic matter (fruit and vegetable peels, food waste), recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), and soiled waste (blood stained cotton, sanitary napkins, disposable syringes) [34-35]. MSW composition at generation sources and collection points ,determined on a wet weight basis, consists mainly of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%). The C/N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg [14].

3.1 Compositional Changes Reported for India since 1971

Changes in the average composition of municipal solid waste for 1971-2005 have been shown in Fig.-5 [31, 36-37]. It suggest that MSW components like Paper, Plastic, Glass are having the increasing trend from 4.1%, 0.7% and 0.4% respectively in 1971 to 8.18%, 9.22% and 1.01 respectively in 2005, metals are also having the increasing trend during the same period while inert materials and compostable matter are having the decreasing trend from 49.2% and 41.3% respectively in 1971 to 25.16% and 40% in 2005. Increasing trend suggest that the establishment of the formal recovery and recycle facilities will be economically a viable option.

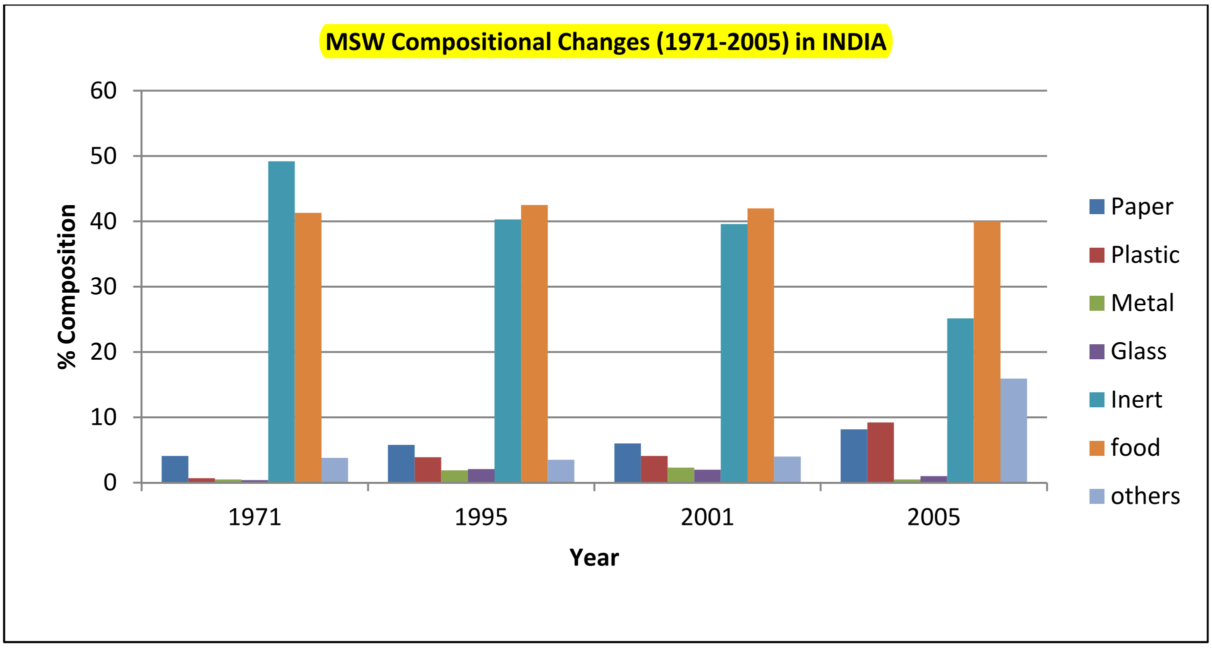
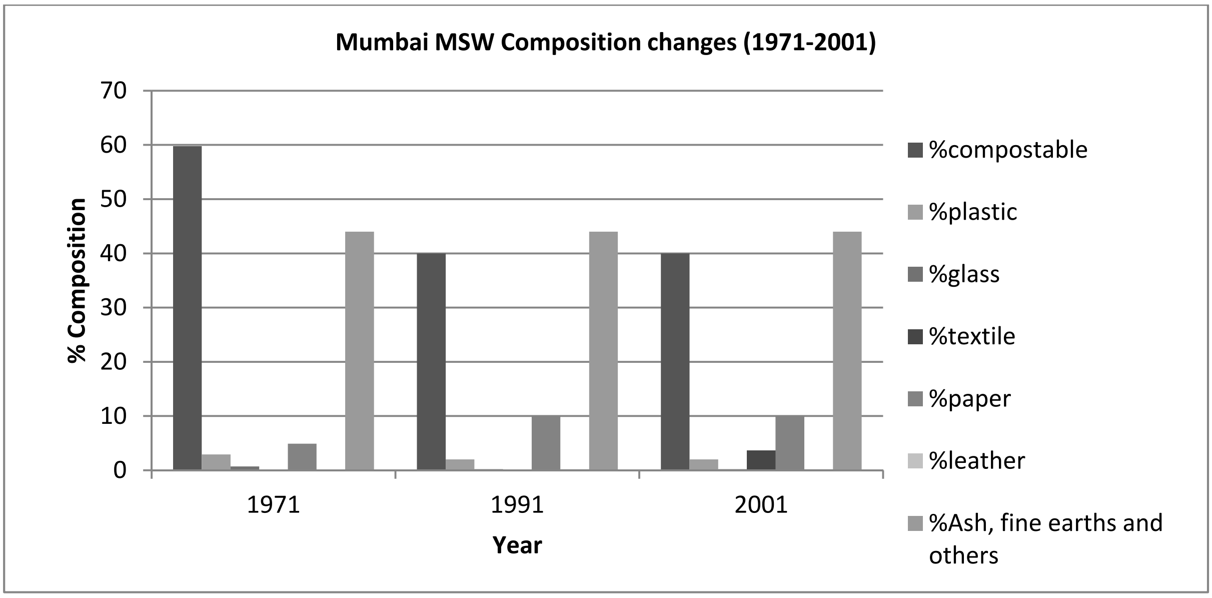


Figure 5

As countries develop economically and become more urbanized, the waste composition undergoes a change as the increase in the paper, paper packaging, plastics, multi material packing items and 'consumer products and decrease in the organic share.

3.2 MSW Compositional changes of Four Mega Cities in India:

Population of Mumbai increased from 8.2 million in 1981, to 12.3 million in 1991, a growth of 49%. However MSW generated, increased from 3.2 to 5.35 Gg per day during the same period, recording a growth of 67% [34]. In Chennai, the population increase was about 21% between 1991 and 2001, while waste generation increased by 61% from 1996 to 2002 [34]. This indicates the rapid increase in municipal waste generation in the Indian mega-cities outpacing the population growth. In Mumbai (Figure 6), Delhi (Figure 7) and Chennai (Figure 8) the compostable matter has a decreasing trend while in Kolkata (Figure 9), it has a slightly increasing trend [34]. Inert material has a decreasing trend in all four mega cities. Plastic and paper are showing the increasing trends in all four mega cities during 1971-2001.



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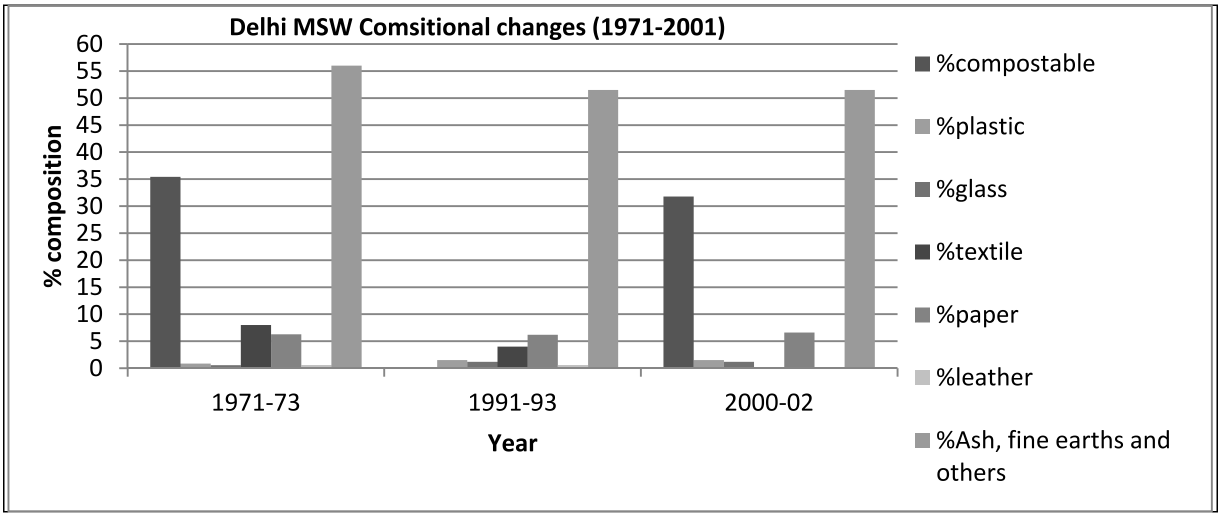

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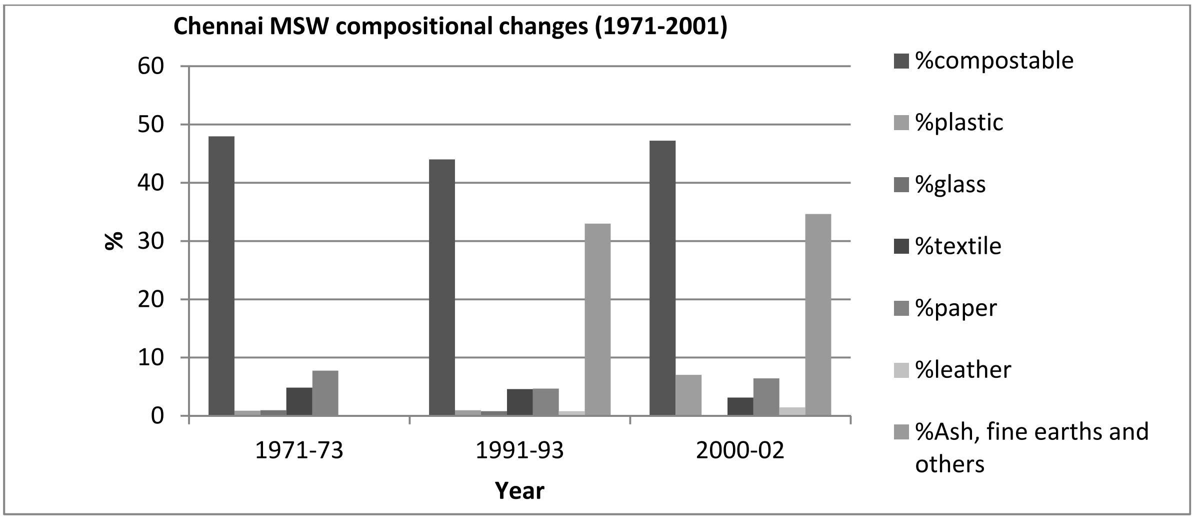

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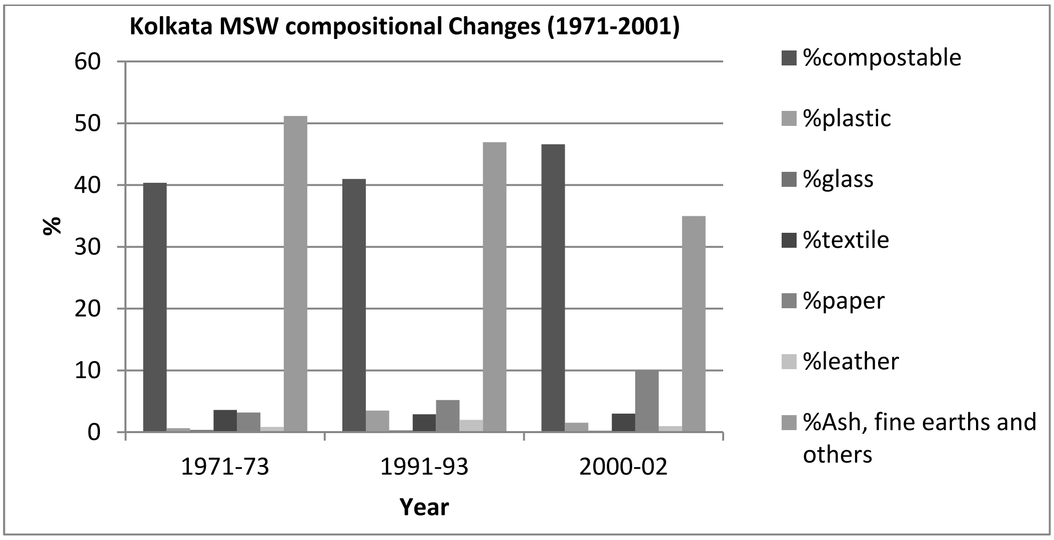

Figure 9

A compositional change on the basis of income of people in low, medium and high income cities has been shown in Figure 10. It suggest that as country gets richer, the organic share decreases whereas the paper and plastic increases.

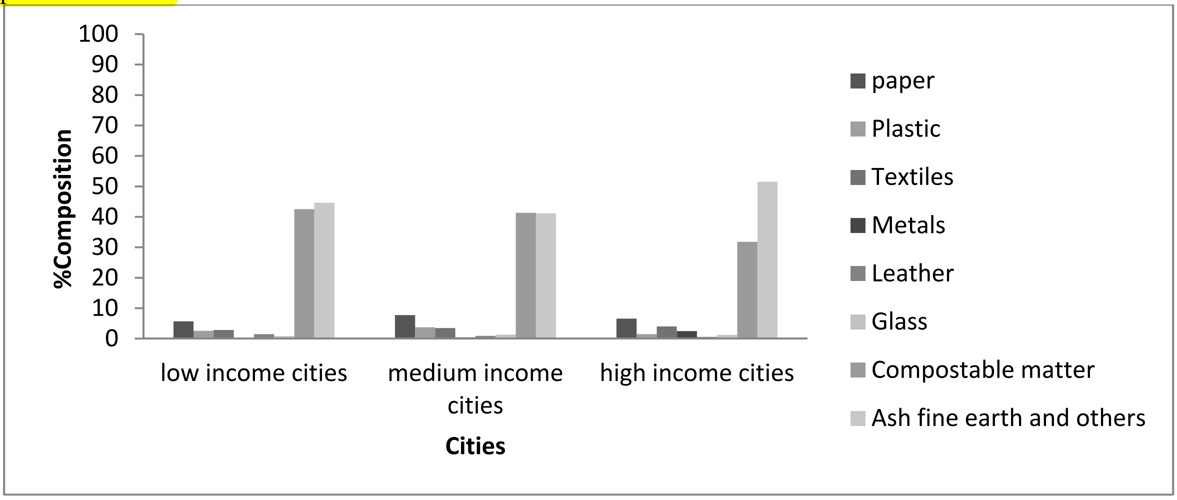

Figure 10

4. Collections and Storage of MSW

In India most of the urban areas are lacking in MSW storage at the source, significantly. For both decomposable and non-decomposable waste common bins are used to collect the waste without any segregation, and disposed off at a community disposal centre. Two types of storage bins are used- movable bins and fixed bins. The fixed bins are more durable but their positions cannot be changed once they have been constructed, while the movable bins are flexible in transportation but lacking in durability [38-39].Collection of MSW is the responsibility of corporations/municipalities. In most of the cities the predominant system of collection (through the communal bins) at various points along the roads, and sometimes this leads to the creation of unauthorized open collection points. House-to-house collection is just starting in many megacities such as Delhi, Mumbai, Bangalore, Madras and Hyderabad with the help of NGOs. Some urban areas are using the welfare associations, on specified monthly payment, to arrange collection. Private contractors for secondary transportation from the communal bins or collection points to the disposal sites, have been employed by many municipalities while other have employed NGOs and citizen's committees to supervise segregation and collection from the generation source to collection points located at intermediate points between sources and dumpsites. The average collection efficiency for MSW in Indian cities and states is about 72%, which shows that the collection efficiency is high in the states, where private contractors and NGOs are employed for the collection and transportation of MSW. Most of the states are unable to provide waste collection services to all cities. [5, 31, 38, 40-41].
In low-income states MSW collection and disposal services are very poor. In these states many practices are often illegal and the people are unwilling or unable to pay for the services. Citizens throw away the waste near or around their houses at different times. It makes the collection and transportation of waste very difficult. The Central Pollution Control Board (CPCB) has found that manual collection comprises 50%, while collection using trucks comprises only 49% [23], in a survey of 299 class-I cities in India.

5. Treatments and Disposal of MSW

India is facing the lacking of resources or the technical expertise necessary to deal with the disposal of MSW. The disposal method trend adopted in India has been shown in Fig. 11[42]. For the years 2001 and 2005, waste dumps or open burning continue to be the principal method of waste disposal. These methods causes several accidents are continuous source of emission of harmful gases and highly toxic liquid leachate.

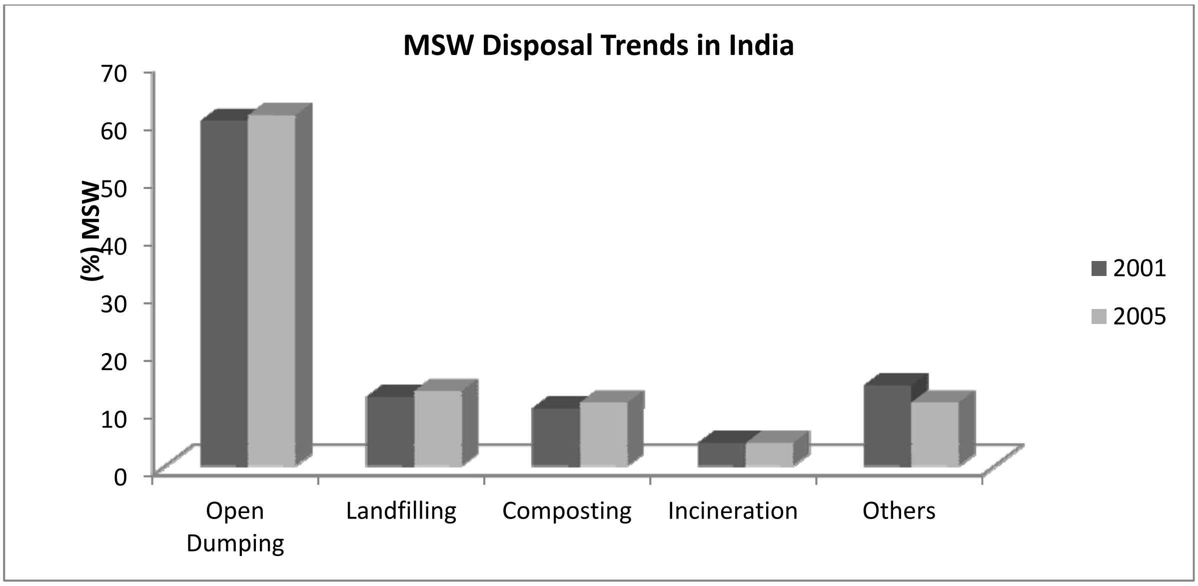

Figure 11

5.1 Composting

Composting has a long tradition particularly in rural India [43].Composting is difficult process because the waste arrives in a mixed form and contains a lot of non-organic material. When mixed waste is composted, the end product is of poor quality. The presence of plastic objects in the waste stream is especially problematic, since these materials do not get recycled or have a secondary market. In the absence of segregation, even the best waste management system or plant will be rendered useless. The first large-scale aerobic composting plant in the country was set up in Mumbai in 1992 to handle 500 t/ day of MSW by Excel Industries Ltd. However, only 300 t/ day capacity is being utilized currently due to certain problems, but the plant is working very successfully and the compost produced is being sold at the rate of 2 Rs. /kg. Another plant with 150 t/day capacity has been operated in the city of Vijaywada, and over the years a number of other plants have been implemented in the principal cities of the country such as Delhi, Bangalore, Ahmadabad, Hyderabad, Bhopal, Lucknow and Gwalior. Many other cities have either signed agreements or are in the process of doing so, to have composting facilities very soon. In India, composting is used around 10-12% because composting needs segregation of waste and sorting is not widely practiced [35, 44].

5.2 Incineration

In India the incineration is a poor option as the waste consists mainly high organic material (40–60%) and high inert content (30–50%) also low calorific value content (800–1100 kcal/kg), high moisture content (40–60%) in MSW and the high costs of setting up and running the plants [18]. The first large-scale MSW incineration plant was constructed at Timarpur, New Delhi in 1987 with a capacity of 300 t/day and a cost of Rs. 250 million (US$5.7 million) by Miljotecknik volunteer, Denmark. The plant was out of operation after 6 month and the Municipal Corporation of Delhi was forced to shut down the plant due to its poor performance. Small incinerators, in many cities in India, are being used for burning hospital waste however [7, 21, 45].

5.3 Gasification Technology

Gasification is the solid waste incineration under oxygen deficient conditions, to produce fuel gas. In India, there are very few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest wastes. Gasification can also be used for MSW treatment after drying, removing the inert and shredding for size reduction. In India one gasification unit installed at Gaul Pahari campus, New Delhi by Tata Energy Research Institute (TERI) and other is installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) for the burning of agro-wastes, sawmill dust, and forest wastes. The waste-feeding rate is about 50–150 kg/h and its efficiency about 70–80%. About 25% of the fuel gas produced may be recycled back into the system to support the gasification process, and the remaining is recovered and used for power generation [9].

trend extension in order to verify the inherent systematic features that are recognized as related to the observed database.

Traditional forecasting methods for solid waste generation frequently count on the demographic and socioeconomic factors on a per-capita basis. The per-capita coefficients were taken as fixed over time or they may be projected to change with time. Grossman et al., (1974) [54] discussed such considerations by including the effects of population, income level, and the dwelling unit size in a linear regression model. The influence of per capita income, population density, persons per house, GDP and population on the composition of the solid waste using linear regression have been established by Khan and Burney (1989) [22]. For year 2025, using subjective judgment based on a single factor GDP of the nation, Gupta et al. (1998) [31] projected the quantity and characteristics of solid waste. However, the quantitative relationship between waste characteristics and GDP was not been established and a subjective judgement was used for prediction. Buenrostro et al. (2001) [55] reported relationship between solid waste composition and socioeconomic factors of community using expert judgements based on secondary data.

Dynamic properties in the process of solid waste generation cannot be fully characterized in those model formulations. Chang et al., (1993) [56] reported the econometric forecasting as one of the alternatives to static models, in which the future forecasts are derived from current forecasts of the independent variables themselves. It covers part of the dynamic features in forecasting analysis. When recycling impact is unparalleled, intervention analysis may account for the varying trends of solid waste generation under uncertainty [48]. The grey dynamic model was developed to resolve the data scarcity issue [57]. It is particularly designed for handling situations in which only limited data are available for forecasting practice and system environments are not well-defined or fully understood. Grey fuzzy dynamic model suitable for the situation when only very limited samples are available for forecasting practice, was demonstrated to handle the dynamic prediction analysis of municipal solid waste generation with reasonable accuracy by Chen and Chang, 2000 [50].

Dynamic MSW generation analysis has been done using time series data of solid waste generated quantities. Esbri J.N. et al., (2001) [58] proposed some tools for time series analysis and forecasting to study MSW generation. A prediction technique based on non-linear dynamics was proposed, comparing its performance with a seasonal Auto Regressive and Moving Average (ARIMA) methodology, dealing with short and medium term forecasting. Dyson B., et al., (2005) [59] presented a system dynamics modelling for the prediction of solid waste generation in a fast-growing urban area based on a set of limited samples. To address the impact on sustainable development city wide, the practical implementation was assessed by a case study in the city of San Antonio, Texas (USA). The analysis presents various trends of solid waste generation associated with five different solid waste generation models using a system dynamics simulation tool – Stella.

Srivastava et al., (2008) [52] reported using Fuzzy regression based approach for forecasting that the percentage of waste paper and food waste is expected to decrease from 29.50 to 24.58 and 36.37% to 27.55%, respectively, between years 2007 and 2024 for the solid waste composition of Delhi, India. On the other hand the waste plastic content is expected to increase from 2.74% to 3.55%. The most significant change is expected with respect to the percentage of metals and glass, which has been estimated to increase to triple and double, respectively. Srivastava et al., (2008) [52] also suggested that while planning the capacities of the solid waste management facilities, maximum possible values should be taken into account, whereas the economic viability of recycle/recovery and compost facilities should be evaluated based on the minimum possible values also the forecasting results signify the importance of controlling the calorific value of the waste so that it should not fall below the rated calorific value of incinerator. The trend of various components (%) of the municipal solid waste in Delhi can be identified from the available and projected data between years 1971 and 2024 (Fig. 12).It can be seen that inert materials and compostable matter are decreasing from 56% to 38.61% and 35.42% to 24.28% respectively while paper, glass and plastic showing increasing trend from 6.29% to 26.66%, 0.57% to 16.53 % and 0.85% to 5.48 % respectively. Kumar et al. (2011) [60] attempted to estimate the quantity of municipal solid waste that can be generated as 39,670 MT per year in municipal cooperation of ELURU city A.P, INDIA by 2026 considering four input variables Population, MSW generated, percentage of urban population of the nation and GDP per capita of the nation in the artificial neural network model.

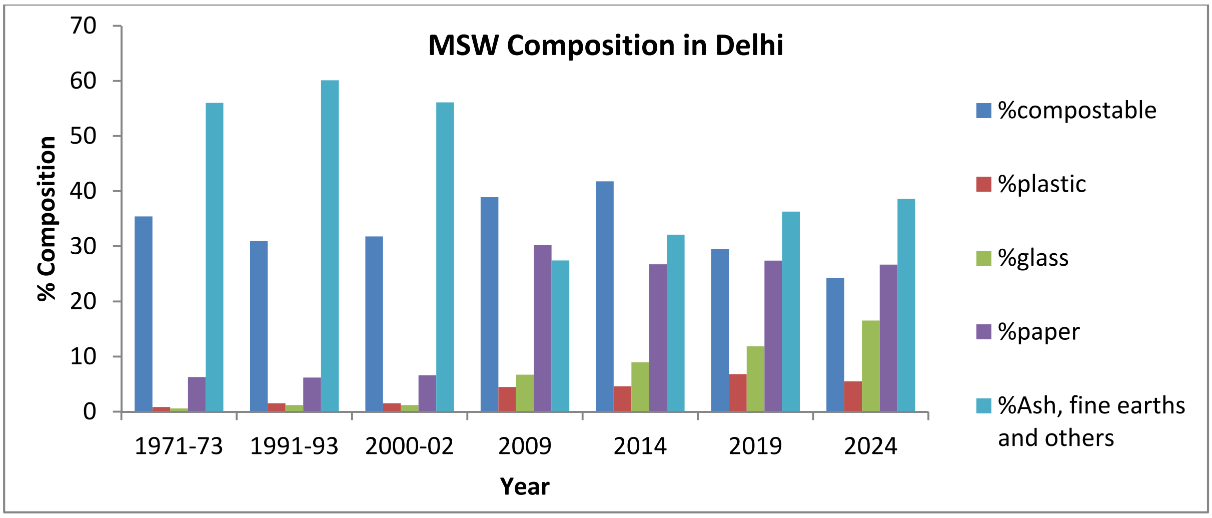

Figure 12

In India some of the future challenges for the management of solid waste are:

7.1 Increasing quantities and changing composition

Due to growth in population, changing lifestyles and consumption patterns, not only the quantity of waste generated is further increasing but quality and composition of waste is also changing particularly more and more hazardous and toxic waste is being generated both because of industrialization as well as end-of-life products. A noticeable change in composition is observed that as the standards of living improve the proportion of paper and plastics increases – in many developing countries it has doubled in one decade.

7.2 Increasing severity of adverse impacts

The negative impacts of wastes on the local environment (air, water, land, human health etc.) are becoming more acute often resulting in public outcries and demands for action. The impacts of inadequate waste management are not just limited to local level but are now crossing boundaries and due cases like methane emission are even affecting global environment. More and more water bodies (both surface waters as well as ground waters) are getting contaminated. The land under and around waste dumps are heavily polluted and will require tremendous efforts and resources for rejuvenation.

7.3 Increasing cost of waste management

Cost of waste management is increasing on several accounts. Firstly, because of the increase in quantity of waste being generated. Secondly, the changing composition of waste with increasing content of non-biodegradable and hazardous substances requires increasing complexity and sophistication in waste management techniques and technologies. Finally, with increasing environmental and health awareness the demands on safe and environmentally sound waste management require more careful and extensive waste management.

7.4 Limited policy framework

As already mentioned, national and local policies on waste management are not yet comprehensive to, cover all types of waste, and all aspects of waste management in India. Policy framework to support resource recovery from waste is still inadequate in India.

7.5 Lack of political priority

In India, waste management loses out to other political priorities of health, education, infrastructure development, job creation, poverty eradication etc. The realization that waste management could be supportive of these issues is often not there.

While these challenges may appear difficult to overcome and may dampen the required initiatives, in today's context, waste management also offers some exciting opportunities.