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Municipal solid waste management in India-Status and Challenges: An overview

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Abstract
Industrialization and population explosion lead to continuous generation and accumulation of solid wastes (degradable and non-degradable). Solid waste is being produced since the establishment of human beings, but the proper management of it remained a big challenge to the world. The main problems of managing this solid wastes are accumulation, segregation, transportation and lack of public awareness. About 70-80% of the generated solid waste has been collected for disposal and rest is remains in the streets, institutions and different places. Accumulation of this waste in nature affects the living and non-living environment adversely. So the need of the day is to manage solid waste properly. The present study describes and evaluates the present status of municipal solid waste management in India.

Keywords: municipal solid waste, generation, management, paper, plastic

Introduction

Due to fast industrialization, population explosion, urbanization and economic growth in India, peoples are migrated towards the cities, which enhance the generation of municipal solid waste around the whole country. Municipal solid waste generation is the natural phenomenon of human life. Municipal solid waste generation is directly proportional to the economic growth of people in terms of kg/capita/day as a consequence of improved life style and social status (Pradeep Kumar and Rajender Kumar Kaushal, 2015) [32]. The continuous increase in population, along with fast industrialization and urbanization directly affects the generated municipal solid waste (Singh and Sharma 2002: Minghua *et al*. 2009) [51, 39]. Now a days the rate of generation of municipal solid waste is highest as compare to any other environmental pollutant generation rate including green house gases (Hoornweg *et al*. 2013) [22]. Being the world's second most populous country the level of urbanization in India, has increased from 27.81% in 2001 to 31.16% in 2011. The continuous increasing population exerts pressure on natural resources for food, shelter and economic growth (Manser and keeling 1996; cointreau 2006a, b; Kathiravale and Muhd Yunus 2008) [37, 6].

Generation and management of solid waste may vary in country to country, state to state, city to city as well as within different areas of the same city. The range of municipal solid waste generation is between 0.3 and 0.6 kg/capita/day in Indian cities and annual increase in municipal solid waste generation by volume is estimated as 1.33% per capita (Patnaik and Reddy 2010) [43]. Municipalities, which are responsible for the management of municipal solid waste in developing countries like India, are facing many problems in providing effective and dynamic system to the society. They mostly fail in such things due to lack of appropriate collection system, lack of technical expertise and in sufficient financial resources (Sujauddin *et al*. 2008; Guerrero *et al*. 2013) [55, 17].

The municipalities use a huge amount of their financial resource in collection of municipal solid waste from different locations of society and very less amount is left for the management of this municipal solid waste (Collivignarelli *et al*. 2004) [8]. In developing countries, the cities hardly spend about 0.5% of their per capita gross national productivity (GNP) on services related to the municipal solid waste management (What a waste 1999).

There are many factors which influence the process of municipal solid waste management, these factors are may be political, legal, socio-cultural and institutional. The most common method, which is generally used in India for the management of municipal solid waste is disposed off in low lying areas or open dumps without necessary precautions. That is why, municipal solid waste management is one of the most challenging environmental issues in India.

Generation of municipal solid waste, global and Indian scenario

In India the current urban MSW production rate is 109,598 tonnes per day (or 0.34 kg/capita/ day) and is assumed to reach to 376,639 tonnes per day (or 0.7 kg/capita/day) by 2025 (Hoornweg and Bhada-Tada 2012) [21]. The survey conducted by the Central Institute of Plastics Engineering and Technology (CIPET) at the instance of CPCB has reported generation of 50,592 TPD of MSW in 2010–2011 in 59 cities of India. As per CPCB, 1,43,449 TPD of MSW was generated for 34 states and union territories during 2013–2014. The average rate of waste generation in India, based on this data, is 0.11 kg/capita/ day. Out of the total waste generated, approximately 1,17,644 TPD (82%) of MSW was collected and 32,871 TPD (22.9%) was processed or treated.

Other studies and observations indicated that waste generation rate is between 200 and 300 gm/capita/day in small towns and cities with a population below 2,00,000. It is usually 300–350 gm/capita/day in cities with a population between 2,00,000 and 5,00,000; 350-400 gm/capita/ day in cities with a population between 5,00,000 and 10,00,000; and 400-600 gm/capita/day in cities with a population above 10,00,000. However, these are only indicative figures which need to be verified while planning city specific MSWM systems.

India produced some 52 million tonnes of waste each year, or roughly 0.144 million tonnes per day, of which roughly 23 per cent is processed-taken to landfills or disposed of using other technologies (CPCB report, 2016)

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 estimated 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. This is not only due to their larger population, but also because their residents are more affluent and bigger generators of waste

The 2004–05 CPCB–NEERI study on waste showed New Delhi, Greater Mumbai and Chennai to be the biggest waste generators in the country, producing 5,922 TPD, 5,320 TPD and 3,036 TPD respectively. In 2011, inventorisation by CPCB again revealed that metro cities, economic hubs of the country, are the biggest waste generators-Delhi: 6,800 TPD, Mumbai: 6,500 TPD, Chennai: 4,500 TPD, Hyderabad: 4,200 TPD, and Kolkata: 3,670 TPD (Down to earth 2016) [12].

Table 1: Municipal solid waste generation in Indian cities (CPCB 2012)

S.N.	City	Municipal solid waste generation (Tons per day)	
		2004-2005^A	2011-2012^B
1	Ahmedabad	1,302	2,300
2	Bangalore	1,699	3,700
3	Bhopal	574	350
4	Bhubaneswar	234	400
5	Chandigarh	326	264
6	Chennai	3,036	4,500
7	Dehradun	131	220
8	Delhi	5,922	6,800
9	Guwahati	166	204
10	Indore	557	720
11	Jammu	215	300
12	Kanpur	1,100	1,600
13	Kolkata	2,653	3,670
14	Lucknow	475	1,200
15	Mumbai	5,320	6,500
16	Patna	511	220
17	Pune	1,175	1,300
18	Shillong	45	97
19	Srinagar	428	550
20	Varanasi	425	450

A. NEERI Nagpur (2004-2005)
B. CIPET (2010-2011)

Table 2: Per Capita Quantity of Municipal Solid Waste in Indian Cities

S.N.	Population	Waste Generation Rate Kg/capita/day
1	Cities with a population < 0.1 million (8 cities)	0.17-0.54
2	Cities with a population of 0.1–0.5 million (11cities)	0.22-0.59
3	Cities with a population of 1–2 million (16 cities)	0.19-0.53
4	Cities with a population > 2 million (13 cities)	0.22-0.62

Source: (Kumar *et al.* 2009)

The increasing rate of migration of people from rural to urban areas and growing economy have enhanced the rate of municipal solid waste generation in developing countries like India (Hassan 2000; Minghua *et al.* 2009; Singh *et al.* 2011b) [39, 20, 52]. Now a days the total amount of solid waste generated by the urban centres of the whole world is around 1,300 million tonnes per year (1.2 kg/capita/day) and it is expected to rise to 2,200 million tons per year by 2025. The municipal solid waste generation rate is greatly influence the Gross national income (GNI) per capita of a country (World Bank 2012) [21, 59, 60].

India, second most populous country aiming to attain an industrialized nation status by 2020 has experienced rapid urbanization and industrialization during the last few decades (Sharma and Shah 2005) [50]. India has total population of over 1.2 billion which accounts for 17.5% of the world population (http: // censusindia.gov.in). About 31.16% Indian population lives in urban areas (Census of India 2011; Sudhir and Gururaja 2012) [4, 54]. The continuous expansion of population as well as migration from rural to urban areas has resulted in rapid boost in solid waste generation. Although, in India municipalities spend about 90% of their total budget on collection of solid waste, yet collection efficiency is very poor about 70-72 % (Nema 2004; CPCB 2012) [41, 42].

Composition of municipal solid waste

The composition and characteristics of municipal solid waste mainly depends on the economic status, living standard, food habits, rituals, literacy rate, type of energy source, climatic and topographical conditions (Jin *et al.* 2006). As compared to western part of the world the characteristics of solid waste in India show great variation in respect of composition and hazardous nature (Gupta *et al*. 1998; Sharholy *et al*. 2008) [19, 49]. The municipal solid waste generated mainly contains organic waste in almost all cases. The highest amount of organic waste was reported in Mumbai (62%), followed by Chandigarh (57%). Other than this, moisture content was also high in all cases (except Ahmedabad) ranging between 41 and 64%. The CV is very low ranging between 742 and 2,632 kcal/kg and the C/N ratio ranging between 18 and 37.

Table 3: Typical composition of municipal solid waste of Indian cities

S.N.	Components	Composition (% by weight)
1	Metal	0.2-2.5
2	Glass, Ceramics	0.5-3.5
3	Food and Kitchen waste	40-65
4	Paper	1-10
5	Textiles	1.5
6	Plastic rubber	1-5
7	Misc. Combustibles	1-8
8	Misc incombustible	-
9	Inert	20-50

Source: Arceivala and Asolekar (2012) [12]

Health Impacts

As a result of continuous increase in municipal solid waste generation and continuous change in its composition, mismanagement, lack of awareness, people are exposed to health risk directly. At the each step of solid waste management like collection, handling and treatment, peoples are associated to health impacts directly or indirectly (Giusti, 2009) [16].

The poor attitude of waste generators in developing countries has made the situation more disgusting. They commonly through their waste on the roads and streets which is further scattered by rag pickers in search of recyclables, and animals (cow, dogs, pigs, etc.) in search of their food. Due to this waste generated by them creates many problems like clogging of drains, stagnant of water which are most favourable conditions for the insect and mosquitoes breeding responsible for the malaria, lymphatic filariasis and other diseases, thus posing risk to human health (Castro *et al*. 2010) [13]. However the evidence that links wastes landfills and incinerator to health problem particularly cancer, reproductive outcomes and mortality is inadequate (WHO 2000, 2007). Nevertheless, this is reported that the impairment of lung function of landfill workers of Okha landfill site, Delhi by 62%, as compared to 27% of the controls which are of the same age, sex and socio-economic conditions. The landfill workers are more susceptible to tissue damage and cardiovascular diseases due to activation of leukocyte and platelets as well as airway inflammation (Ray *et al*. 2005, 2009) [47, 48].

Environmental impacts

The decomposition of solid waste into constituent chemicals is a common source of its local environmental pollution. In developing countries this problem is very acute. In the whole world very few existing landfills of poorest countries would meet environmental standards accepted in industrialised nations, and there are likely to be few sites rigorously evaluated prior to use in the future with limited budgets. This problem becomes more serious in terms of rapid urbanization. Gas release by the decomposing garbage is the main environmental problem created by municipal solid waste. Due to high moisture content of municipal solid waste, bacteria release methane as a by product of the anaerobic respiration. As a result of maximum anaerobic decomposition the concentration of methane can reach up to 50% of the composition of gas released from the landfill site (Cointreau-Levine, 1997) [7]. The enhanced greenhouse gas effect and climate change is the second problem caused by these generated gasses from the landfills. The management of liquid leachate produced by the municipal solid waste at the site is varies country to country in developing world. Leachate can be contaminate the local surface and ground water system. To prevent infiltration into the surrounding soil, the use of dense clay deposits at the bottom of waste pits, coupled with plastic sheeting-type liners, is generally regarded as the optimum strategy to contain excess liquid. These are the reasons why waste is encouraged to evaporate rather than infiltrate.

Soil properties and its yield are badly affected by increasing rate of municipal solid waste generation. In cities of developing countries this problem is very common. It is reported that the concentration of heavy metals (Mn, Zn, Cu, Cd, Ni, Pb and Cr) is increased in soil and road dust samples from Kanpur city, this might me deposition of dust from industries (Rawat *et al*. 2009) [45].

Due to rapid increased urbanization, industrialization and improper management of solid waste, on one side the world is facing fresh water scarcity, on the other hand whatever the remaining ground water resources are available, is facing critical stress in quality. Other than this, inadequate maintenance of distribution system also pollutes drinking water. Different physicochemical parameters of ground water quality in Erode city, Tamil Nadu, India was compared with Bureau of India standards (BIS) and world health organization standards (WHO) and had observed increased concentration of constituents like total dissolved solid (TDS), total hardness (TH), Total alkalinity (TA), Sodium (Na^+), Magnesium (Mg^+), Chloride (Cl^-), Fluoride (F^-) and Nitrate (NO_3^-) above the upper permissible limit for drinking purpose making the water not potable (Nagarajan *et al*. 2012) [40].

When municipal solid waste undergoes anaerobic decomposition in landfills, leading to production of landfill gas. The landfill gas mainly consists of about CH4 and CO_2

together with small amount of volatile organic compounds and other trace gases. Due to having green house gas effect nature of the both gases, it have global warming potential, which is 25 times higher in CH4 than global warming potential of CO_2 with atmospheric residence time of 12 ± 3 years (IPCC 2007) [24].

Collection and storage of municipal solid waste

In the country most of the urban areas are lacking municipal solid waste storage at the source, significantly. There are common bins used to collect the waste (compostable and non-compostable) without any segregation, and disposed off at a community disposal centre. Movable and fixed bins are two types of storage bins commonly used. Because of the position of fixed bins cannot be changed once they have been constructed, are more durable. Due to the flexibility in transportation, the movable bins are not very much durable (Nema, 2004 and Malviya, 2002) [41, 42]. Corporation/ municipalities are responsible the collection of municipal solid waste. The predominant system of collection (through the communal bins) at various points along the roads in most of the cities, and some time this leads to the creation of unauthorized open collection points. In many megacities such as Delhi, Mumbai, Bangalore, Madras, and Hyderabad, just start the house-to-house collection with the help of NGOs. To arrange collection of municipal solid waste, some urban areas are using the welfare association, on specified monthly payment. Privet 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 source and dump sites. Where privet contractors and NGOs are employed for the collection and transportation of municipal solid waste, the average colletion efficiency for municipals solid waste in Indian cities and states is about 72%, which shows that the collection efficiency is high in the states. Most of the states are unable to provide waste collection services to all cities (Rathi 2006, Gupta *et al*. 1998, Nema 2004, Maudgal 1995 and UNEP 2001) [41, 42, 19]. The municipal solid waste collection and disposal services are very poor in low income states. Many practices are often illegal and the people are unwilling or unable to pay for the services in these states. Citizens through away the waste near or around their house at different times, it makes the collection and transportation of waste very difficult. The central pollution control (CPCB) has found that manual collection comprises 50% while collection using trucks comprises only 49% (CPCB-2002), in a survey 299 class one cities in India.

Treatment and disposal of municipal solid waste

To deal with the proper management of municipal solid waste, India is facing the problem of lack of resources or the technical expertise necessary to deal with it. There are many methods of municipal solid waste disposal, which are used in country.

1-Incineration

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 municipal solid waste and the high costs of setting up and running the plants (Kansal, 2002) [29]. In 19187 the first large-scale municipal solid waste incineration plant was constructed at Timarpur, New Delhi, with a capacity of 300 t/day and a cost of Rs. 250 million (US$5.7 million) by Miljotecknik volunteer, Denmark. The municipal corporation of Delhi was forced to shut down the plant due to its poor performance after 6 months. In India in many cities, small incinerators, are being used for burning hospital waste however (Sharholy, 2006; Dayal, 1994; Lal, 1996) [49, 11, 34]

2-Pyrolysis and Gasification Technologies

Pyrolysis and gasification both are endothermic process. The end products are gas in both the processes termed as syngas, liquid (containing acetic acid, acetone and methanol) and char (containing carbon with inert material). To produce fuel gas from the solid waste we use gasification, which is a type of incineration under oxygen deficient condition. There are very few gasifiers in operation in India, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest waste. Gasification can also be used for municipal solid waste treatment after drying, removing the inert and shredding for size reduction. For the burning of agro-waste, sawmill dust, and forest wastes in India one gasification unit installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) and other is installed at Gaul Pahari campus, New Delhi by Tata Energy Research Institute. Its efficiency is about 70-80% and the waste feeding rate is about 50-150 kg/h. 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 (CPCB, 2004).

3-Landfilling

Landfill is a vacated land area onto or into which waste is disposed. It is an essential part of any planned municipal solid waste management system. After pertinence of all available management options, they are the final depot of any city’s municipal solid waste. In most of the developing countries, open dumping is the most, lucid and economical practice is implemented. Among all available management practices, about 51% open dumping takes place in Asia (World Bank 2012) [21, 59, 60].

The aim of landfilling of municipal solid waste is to avoid any contact between the solid waste and the surrounding environment, particularly the ground water. There are three types of landfills, which are-

A-Open dumps or open landfills

These are the most common in almost all developing countries, involve the refuse simply being dumped haphazardly into low lying area of open land.

B-Semi-controlled or operated landfills

These are designated sites where the dumped refuse is compacted and a top soil cover is provided daily to prevent nuisance. In this type of landfills, all kinds of municipal, industrial and clinical hospital wastes are dumped without segregation. The management of leachate discharge or emissions of landfill gases is not engineered in this type of landfills.

C-Sanitary landfills

This type of landfills have facilities for interception and treatment of the leachate using a series of ponds, and generally used in developed countries. For the control of gases from the waste decomposition, this type of landfill have arrangement (Tchobanoglous *et al.*, 1993).

4-Bioreactor landfill

A bioreactor landfill is a further development in landfill technology. These types of landfills are mainly designed, constructed and operated for optimization of moisture content and increasing the rate of anaerobic biodegradation. Leachate recirculation is the principal function that make bioreactor landfills different from conventional landfills. The main goal of formation of bioreactor landfills is to increase the rate of bio-degradation to achieve maximum gas generation rate and output so as to optimize recovery for energy production. This method is also reduce the period of monitoring and inability and also aims to minimise the landfill stabilization time. While permitting and encouraging rapid stabilization of the readily and moderately decomposable organic waste components, the bioreactor option is a direct result of engineering and building a new generation of environmentally sound landfills; it provides environmental security (Gupta *et al*., 2007) [18].

5-Refuse Derived Fuel (RFD) Plants

In this method municipal solid waste produces an improved solid fuel or pallets. This plant reduces the pressure on landfills. Combustion of the RFD from municipal solid waste is technically sound and generating power. Without any ill effects for generating heat, RDF may be fired along with the conventional fuels like coal. Operation of the thermal treatment system not only costly but also a relatively higher degree of expertise. In the country many plants are in operation, in Bangalore RFD plant was established and has regular production of fuel pallets since October, 1989, compacting 50t/day of garbage, converting in to 5t of fuel pallets, which can be designed both for industrial and domestic uses. For processing garbage into fuel pallets, the RDF plant at Deonar, Mumbai was set up in the early 1990s. It is based on indigenous technology. However, at present the plant has not been in operation for the last few years and it is owned by Excel India. The Hyderabad RDF plant was commissioned in 1999 near the Golconda dumping ground with a 1000t/day capacity (but receiving only 700 t/day at present). The RDF production is about 210t/day as fluff and pellets, and it is going to be used for producing power (about 6.6 MW) (Yelda and Kansal, 2003) [61].

6-Composting

Particularly in rural India composting is used traditionally for disposal of solid waste (Howard, 1943) [23]. Due to presence of a lot of non-organic materials in waste, it is difficult to compost it. The quality of end product is very poor if solid waste is composted as such (mixed waste). The presence of plastic goods in solid waste is especially problematic, since these materials do not get recycled or have a secondary market. Even the best waste management system or plant will be rendered useless, in the absence of segregation. In the country the first large-scale aerobic composting plant was setup in Mumbai in 1992 to handle 500t/day of municipal solid waste 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 has been operated in the city of Vijaywada with 150t/day capacity, and a number of other plants have been implemented in the principal cities of the country such as Delhi, Bangalore, Ahmadabad, Hyderabad, Bhopal, Lucknow and Gwaliar over the years. To have composting facilities very soon, many other cities have either signed agreements or are in the process of doing so. Due to composting needs segregation of waste and shorting is not widely practiced, there is only 10-12% composting is used in India (Reddy and Galab, 1998; Sharholy *et al*. 2006) [49, 48].

7-Vermicomposting

Vermicomposting is an eco-friendly, eco-biotechnological and bio-oxidative process which stabilizes organic solid waste into valuable bio-product, called vermicompost. In this process there is an inter-mutual action of earthworms and microorganisms. The microbial biomass present in the earthworm's gut is also responsible for the biochemical decomposition of organic matter, in addition to the feedstock. Earthworms are responsible for alteration of physical status of organic waste directly and chemical status indirectly by acting as important mediators which increase accessible surface area to microorganism, thereby improving enzymatic action (Malley *et al*. 2006; Fornes *et al*. 2012) [35, 14]. Other than this to colonise surrounding microbes supporting microbial growth and action, earthworms provides suitable organic substrate by producing faecal matter (Williams *et al*. 2006) [58]. Earthworms have a major role in solid waste management plus soil management, as they are considered as the biological indicator of soil health (Ismail, 1997). Earthworms decrease the stabilization time of household waste and sewage sludge by vermicomposting and turned them into valuable end product i.e. vermicompost that can be further utilized in agricultural and horticultural practices (Kale *et al*. 1982; Ismail 1993; Edward *et al*. 1995; Ismail 2005; Ansari and Ismail 2008) [28, 13], thus improving the productivity and fertility of soil (Edward *et al*. 1995) [13].

Problems in municipal solid waste management

1- Source segregation, collection

Except for industrial waste where due to organized nature of sector, segregation is sometimes practiced and for healthcare waste due to regulatory requirements, there is virtually no organized and scientifically planned segregation source in India. Sorting is mostly done by unorganized sector (scavengers and rag pickers) and rarely done by waste generators. Therefore, the efficiency of segregation is quite low as the unorganized sector tends to segregate only those waste materials which have relatively higher economic return in the recycling market. The unsafe and hazardous conditions under which the segregation and sorting takes place are well known. The waste collection efficiency even in high income cities (i.e. Delhi) is rather low. Often a substantial amount of waste is left to rot on the streets and/or dumped in to low lying areas, canals, rivers etc. Lack of appropriate collection system, lack of and/or inadequate collection facilities such as waste disposal bins, collection vehicles etc., lack of funds, lack of and enforcement of appropriate regulation etc. are the main factors are responsible for such low collection efficiency.

2- Treatment and disposal

Municipal solid waste is generally disposed as such without any treatment. Most of the municipal solid waste is still disposed of in dumps causing sever environmental and health risks. The progress in moving towards sanitary landfills and/or disposing through well designed and well operated incinerators is rather slow.

3- Policy Issues

In India there is no any vigorous policy framework to give a direction and thrust to environmentally sound waste management. Policy measures to promote waste minimization, recycle and recovery are rather lean. To deal with overall issue of waste management in line with country's economic development programme, there is no any national target has been set up. The environmental policies are 'discharge end control' based instead of shifting to 'source end control' based approach. The industrial policies continue to rely on manufacturing from virgin resources and a rational pricing mechanism and/or market based instruments to accelerates waste minimization and support greater use of recycled materials are not in place. Most of the current policies are in support of end-of-pipe approach creating huge burden on municipal authorities. At source and conversion of waste into useful materials/energy, there are no policies to promote segregation and reuse of municipal solid waste.

4- Technology Issues

In India, it is need of the day to launching targeted efforts for development/acquisition of technologies for material and energy recovery from municipal solid waste. To built confidence and test the application of such technologies in the context of developing countries pilot demonstration projects need to be established. To facilitate assessment of recycling /recovery potential and design/development of technologies, this in turn will require extensive data collection on waste characterisation and quantification. In this direction almost no efforts seems to be taking place. Most of the work is focussed on augmenting waste collection and building disposal facilities.

5- Financing Issues

One of the most pressing issues is the availability of funds to support waste management. The local authorities are mostly in a dire financial situation and are barely able to maintain the basic jobs of waste collection and some how dispose it. Municipal level waste management continues to be heavily subsidised by governments. To promote use of environmentally sound technologies, for technology development and demonstration are conspicuous by absence.

Future challenges in municipal solid waste management

A successful long term planning depends on the characteristics of the solid waste and estimation of future quantities. In future the decisions related to treatment choices and disposal options for solid waste management will get affected by the composition of solid waste. To address the issue of forecasting the quantities of municipal solid waste, researchers have been reported for innovative and forward looking solution (Chang and Lin, 1997; Srivastava and Nema, 2005) [53]. Although both planning and design of municipal solid waste management system require accurate prediction of solid waste generation. Yet achieving the anticipated prediction accuracy with regard to the generation trends facing many fast-growing regions is quite challenging. A long time forecast will be more meaningful if it gives the most optimistic, most pessimistic values and also the most likely values (Fung *et al*., 2003) [15]. In India some of the future challenges for the management of municipal solid waste are, (1) Increasing quantities and changing composition (2) Increasing severity of adverse impacts (3) Increasing cost of waste management (4) Limited policy framework (5) Lack of political priority

Summary

An attempt has been made to study the changing trends of quantity and characteristics of municipal solid waste to find its impact on the performance and capacity planning of recovery/recycle, compost, incineration and landfill facilities. For successful operation of waste management facilities, the changing pattern of waste composition emphasises the importance of segregation. Municipal authorities should maintain the storage facilities in such a manner that they do not create unhygienic unsanitary conditions. In the country, a new survey should be carried out on the generation and characterization of municipal solid waste. A large number of samples have to be collected and analyzed to obtain statistically reliable results, since the municipal solid waste is heterogeneous in nature.

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