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# A Review on the Recent Scenario of Municipal Solid Waste Management in India

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**Abstract**— The rapid pace of increasing population, economic growth, urbanization and industrialization is coupled with accelerated solid waste generation. Waste generation has been a part and parcel of the development activities of mankind. Municipal Solid Waste (MSW) is an example of socioeconomic activities that entails with solid waste generation. Management of municipal solid waste is a national problem and is faced in all the cities of India. Two of the major problems being encountered are the insufficient collection and inappropriate final disposal of MSW. Various collection systems employed by the municipalities collect less than half of the total waste generated. As a result, wastes are either scattered in urban centers or disposed of in an unplanned manner in low lying areas or open dumps, or burned by the residents in their backyards. Insufficient collection and inadequate have made the situation exasperating due to which several environmental and health related problems are increasing. Keeping in mind of the present situation, the current review examines the opportunities and improvements that could be brought about in MSW management (MSWM) system in the country.

**Keywords**— Frameworks, Improvements, MSW, MSWM, Opportunities, Problems, Urbanization.

## I. INTRODUCTION

Cities in the developing world have undergone a rapid urbanization during the past 50 years [1]. India, 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 [2]. Urbanization in developing countries like India implies the expansion of existing slum areas and the creation of new ones. Future need for waste collection in slums, therefore, is likely to put additional strain on municipalities already unable to provide the service to their current residents. The ever rising population is putting immense pressure on demand for food, shelter and other natural resources [3]. It also intensifies the pressure on urban infrastructure in many cities already overburdened with the provision of urban services. Many cities lack the resources to meet the demand for services such as water, sanitation, and municipal solid waste management (MSWM).

MSWM is one of the most overlooked basic services provided by the Government of India. Generation and characteristics of MSW may vary at the level of country, state, city as well as within different areas of the same city. MSW generation rates range between 0.3 and 0.6 kg/ capita/day in Indian cities and annual increase in MSW generation (volume) is estimated as 1.33 % per capita [4].

Of the total waste generated, less than half of the waste are collected. Worldwide, over two thirds of human waste are released into the environment with little or no treatment, resulting in a deterioration of the urban environment in the form of air, water, and land pollution that pose risks to human health and the environment [5].

MSWM has received less attention from policymakers and academics than that paid to other urban environmental problems, such as air pollution abatement and wastewater treatment. Nevertheless, the improper handling and disposal of solid waste constitutes a serious problem: it contributes to the high morbidity and mortality rates in many cities. Some have emphasized the involvement and role of a number of government stakeholders like Ministry of Environment and Forest (MoEF), Ministry of Urban Development (MoUD), Ministry of agriculture, Ministry of New and Renewable Energy and Ministry of Non-Conventional Energy Sources (MNES) in MSWM [6]. Besides, the involvement of formal and informal sector could help MSWM [7].

This paper examines the conditions of the current MSWM trends in India and analyzes and suggests the opportunities that exist in improving the management of MSW in many Indian cities.

## II. MSW CHARACTERIZATION

Municipal solid waste (MSW) is waste that comes from homes, businesses, and schools. Municipal solid waste does not include construction waste, industrial waste, or sewage waste.

MSW classification

- By Material -what the waste is made of. Waste may be plastic, paper, metal, rubber, food waste, or yard waste. A plastic toy and a plastic yogurt carton would be in the same materials category because they are both made of plastic.
- By Product - what the waste was used for originally. The waste may be an old potato chip bag, a worn-out shoe, or a broken toy. A plastic beverage container and an aluminum beverage container would be in the same product category because they are both used as container.

Knowledge of the sources and types of waste in an area is required in order to design and operate appropriate solid waste management systems (Table-1).

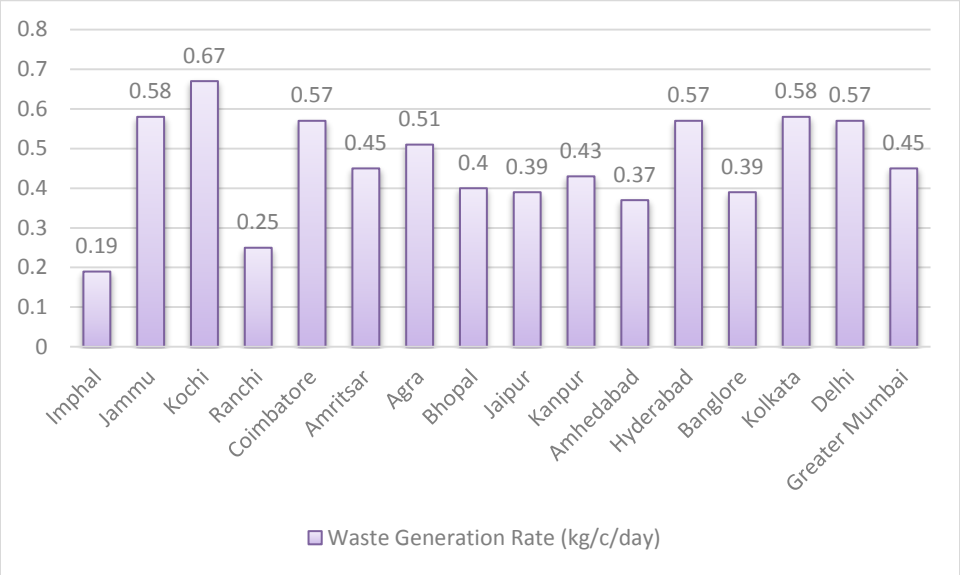
**Table-1: Sources and Types of MSW**

| Source | Typical waste generators | Types of solid wastes |
|---|---|---|
| Residential | Single and multifamily dwellings | Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes |
| Industrial | Light and heavy manufacturing, fabrication, construction sites, power and chemical plants | Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes |
| Commercial | Stores, hotels, restaurants, markets, office buildings, etc. | Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes |
| Institutional | Schools, hospitals, prisons, government centers | Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes |
| Construction and demolition | New construction sites, road repair, renovation sites, demolition of buildings | Wood, steel, concrete, dirt, etc. |
| Municipal services | Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants | Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge |
| Process | Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing | Industrial process wastes, scrap materials, off-specification products, slag, tailings |

As is shown in the above table, MSW includes wastes generated from residential, commercial, industrial, institutional, construction, demolition, process, and municipal services. However, this definition varies greatly among waste studies, and some sources are commonly excluded, such as industrial, construction and demolition, and municipal services. Most often only residential waste is referred to as MSW [8].

**2.1 Waste Generation Rates**

Waste generation rates are affected by socioeconomic development, degree of industrialization, and climate. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of MSW produced. Fig-1 gives MSW generation rates in some of the selected Indian cities.




*Source: CPCB, GOI (2004-2005) [9]*

**Fig-1: Waste generation (kg/day) per capita in selected cities**

During the year 2004-05, CPCB through NEERI, conducted survey in 59 Indian cities and estimated 39,031 tons per day MSW generation in these 59 cities. In the year 2010-11 in these same 59 cities, a survey was conducted by the Central Institute of Plastics Engineering and technology (CIPET) at the instance of CPCB. The report has recorded a MSW generation of 50,592 tons per day. These results show that generation of MSW has increased by 77.1% from 2005 to 2011 in cities [10].

A very little information about rural waste generation rates is available; however, one can assume that rural populations will generate less waste because these areas have lower per capita incomes. Urbanization and rising incomes, which lead to more use of resources and therefore more waste, are the two most important trends that factor into rising waste generation rates. Fig-2 exemplifies this trend. Individuals living in Indian urban areas use nearly twice as many resources per capita than those living in a rural setting because they consume and generate more solid waste.

**2.2 MSW Composition**

The composition of municipal solid waste varies widely within countries, and between different seasons of the year. It is influenced by external factors, such as geographical location, the population's standard of living, energy source, and weather. Table-2 presents the current MSW compositions for some of the Indian cities.

**Table-2: The composition of MSW in some of the selected Indian cities (% by weight)**

| Major Cities | Paper | Metal | Glass | Textiles | Plastics* | Ash and dust | Organic | Others** |
|---|---|---|---|---|---|---|---|---|
| Chennai | 5.90 | 0.70 | - | 7.07 | - | 16.35 | 56.24 | 13.74 |
| Delhi | 5.88 | 0.59 | 0.31 | 3.56 | 1.46 | 22.95 | 57.71 | 7.52 |
| Kolkata | 0.14 | 0.66 | 0.24 | 0.28 | 1.54 | 33.58 | 46.58 | 16.98 |
| Bangalore | 1.50 | 0.10 | 0.20 | 3.10 | 0.90 | 12.00 | 75.00 | 7.20 |
| Ahmedabad | 5.15 | 0.80 | 0.93 | 4.08 | 0.69 | 29.01 | 48.95 | 10.39 |
| Mumbai | 3.20 | 0.13 | 0.52 | 3.26 | - | 15.45 | 59.37 | 18.07 |

*Source: Planning Commission on Urban Solid Waste Management in India", GOI (1995) [11]*

*includes rubber and leather

**includes bones, stones and woody matter

### 2.3 Recent Trends in MSWM in India

MSW quantities are inextricably linked to economic activity and resource consumption. If the lagging non-OECD (Organization for Economic Co-operation and Development) countries are able to transition to a sustainable higher growth path, the global poverty ratio will fall from about 21 percent in 2005 to less than 2.5 percent in 2050 [12]. As the economy prospers, the overall MSW generation rates will dramatically increase.

The importance of proper solid waste management is one of the prime functions of the civic body, as insanitary management of solid wastes is a cause of much discomfort. Since waste management is a fundamental requirement for public health. Article 48-A of the Indian Constitution establishes the responsibility of the state to manage these wastes properly. [13-15]

- About 0.1 million tonnes of municipal solid waste is generated in India every day. That is approximately 36.5 million tonnes annually.
- Per capita waste generation in major Indian cities ranges from 0.2 Kg to 0.6 Kg.
- Difference in per capita waste generation between lower and higher income groups range between 180 to 800 gm per day.
- The urban local bodies spend approximately Rs.500 to Rs.1500 per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on collection, 20-30% on transportation and less than 5% on final disposal.
- Calorific value of Indian solid waste is between 600 and 800 Kcal/Kg and the density of waste is between 330 and 560 Kg/m3.
- Out of the total municipal waste collected, on an average 94% is dumped on land and 5% is composted.
- Between 2000 and 2025 the waste composition of Indian garbage will undergo the following changes:
    - *Organic* Waste will go up from 40 percent to 60 percent
    - *Plastic* will rise from 4% to 6%
    - *Metal* will escalate from 1% to 4%
    - *Glass* will increase from 2% to 3%
    - *Paper* will climb from 5% to 15%
    - *Others* (ash, sand, grit) will decrease from 47% to 12%

## III. ENVIRONMENTAL AND HEALTH IMPACTS OF IMPROPER MSWM

Improper MSWM causes all types of pollution, whether be it air, soil, or water. It does not end here. Their impacts on economy, environment and society are mentioned in Table-3.

**Table-3: Economic, Environment and Social impacts of MSWM**

| Economic impacts | Environment impacts | Social impacts |
|---|---|---|
| • Function of the internal market<br>• Investment costs<br>• Operating costs<br>• Administrative burdens<br>• Public authorities<br>• Property rights innovation and research<br>• Economic effects on consumers and households<br>• Economic effects on industry and business | • Climate<br>• Energy<br>• Air quality<br>• Biodiversity, flora, fauna, and landscapes<br>• Water quality and resources<br>• Soil quality or resources<br>• Land use<br>• Renewable or non-renewable resources<br>• Environmental consequences of firms and consumers<br>• Likelihood or scale of environmental risks<br>• Animal welfare | • Social inclusion and protection of particular groups<br>• Non-discrimination<br>• Individuals, private and family life, personal data<br>• Governance, participation, good administration, access to justice, media, and ethics<br>• Public health and safety<br>• Security<br>• Access to and effects on social protection, health, and educational systems<br>• Culture |

People know that poor sanitation affects their health, and nowhere is this link more apparent than in developing countries like India. MSW that is not properly managed, especially excreta and other liquid and solid waste from households and the community, are a serious health hazard and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats, and other creatures that in turn spread disease.

**Table-4: Occupational hazards associated with waste handling**

| Infections | Chronic diseases | Accidents |
|---|---|---|
| • Skin and blood infections resulting from direct contact with waste, and from infected wounds.<br>• Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations.<br>• Different diseases that results from the bites of animals feeding on the waste.<br>• Intestinal infections that are transmitted by flies feeding on the waste. | • Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds. | • Bone and muscle disorders resulting from the handling of heavy containers.<br>• Infecting wounds resulting from contact with sharp objects.<br>• Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste.<br>• Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites. |

## IV. FUNCTIONAL ELEMENTS OF MSWM

To implement proper MSWM, various aspects have to be considered such as waste generation, storage and collection, processing, transfer and transport, and disposal and disposal options. Fig-2, shows the interrelationship between the functional elements in MSWM.

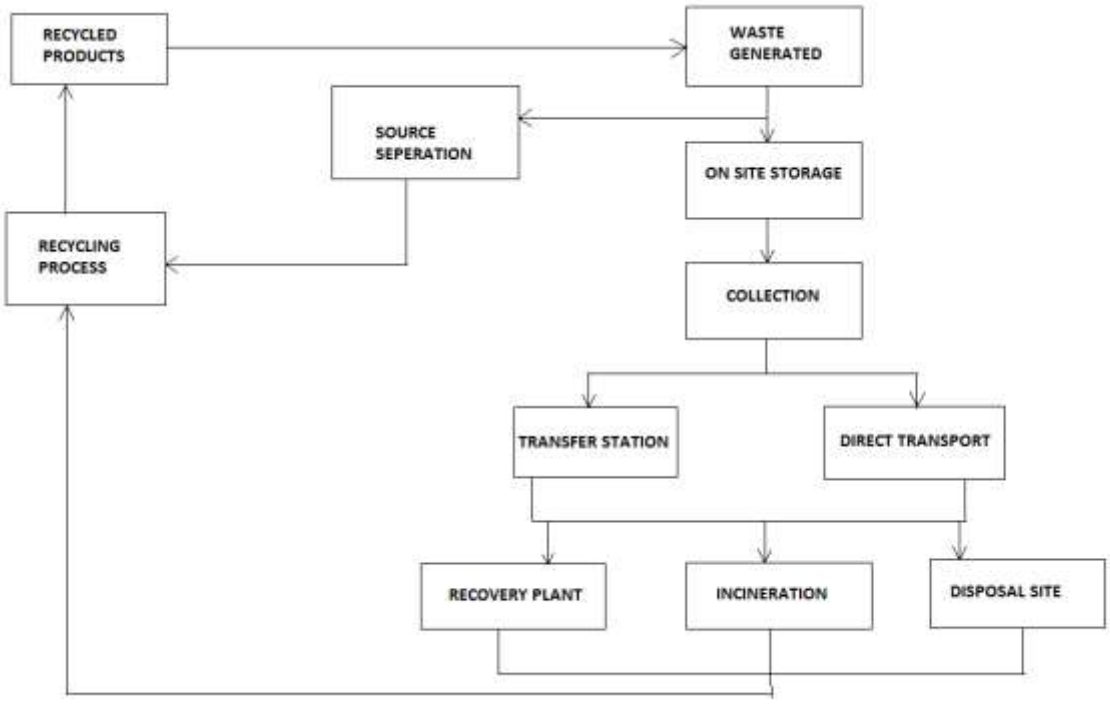



**Fig-2: The interrelationship between the functional elements in MSWM**

### 4.1 Waste Generation and Its Storage

Storage of MSW at the source is substantially lacking in most of the urban areas [16]. Municipal Solid Waste is commonly stored in circular concrete open bins in India. There have hardly been any studies conducted on the most suitable type of storage bin for the Indian waste. The waste should be preferably stored in closed bins and for not more than 24 hours, as the Indian waste has high organic content and is highly putrescible [17].

### 4.2 Waste Collection

The collection of MSW is the responsibility of corporations/municipalities. The waste collection methods that are mainly adopted in India are given in Table-5 with their key features.

**Table-5: Key Points Concerning Main Collection Systems**

| System | Description | Advantages | Disadvantages |
|---|---|---|---|
| **Community Bins** | Users bring their garbage to community bins that are placed at fixed points in a neighborhood or locality. MSW is picked up by the municipality, or its designate, according to a set schedule. | Low capital costs | Loading the waste into trucks is slow and unhygienic. Waste is scattered around the collection point. Adjacent residents and shopkeepers protest about the smell and appearance. |

| | | | |
|---|---|---|---|
| **House-to-House** | Waste collector knocks on each door or rings doorbell and waits for waste to be brought out by resident. | Convenient for resident. Little waste on street. | Residents must be available to hand waste over. Not suitable for apartment buildings because of the amount of walking required. |
| **Curbside Pick-Up** | Waste is left outside property in a container and picked up by passing vehicle, or swept up and collected by sweeper. | Convenient. No permanent public storage. | Waste that is left out may be scattered by wind, animals, children or waste pickers.<br>If collection service is delayed, waste may not be collected or some time, causing considerable nuisance. |
| **Block Collection** | Collector sounds horn or rings bell and waits at specified locations for residents to bring waste to the collection vehicle. | Economical. Less waste on streets. No permanent container or storage to cause complaints. | If all family members are out when collector comes, waste must be left outside for collection. It may be scattered by wind, animals and waste pickers. |

Community Bins has been the most commonly adopted method in India [7]. Efforts to organize house-to-house collection method are just starting in many cities such as Delhi, Mumbai, Bangalore, Madras and Hyderabad with the help of NGOs. A case study conducted on door-to-door collection through RWAs and NGOs in Ahmedabad met with success. Ahmedabad has a population of 4 million and its average rate of waste generation is 2,096 metric tonnes per day. The city estimated that 3,900 sanitary workers would be required for ensuring door-to-door collection. So the municipal corporation sought for applications from RWAs and NGOs. The entire city is now covered in door-to-door collection after less than six months of concerted effort [18]. The same system has been adopted in Chennai [19]. From these studies, it has been observed that the door to collection method has improved the efficiency of collection of segregated waste.

Many studies on urban environment have revealed that MSW collection efficiency is a function of two major factors: manpower availability and transport capacity [20]. The collection efficiency ranges between 70 to 90% in major cities and states, where private contractors and NGOs are employed for the collection and transportation of MSW whereas in several smaller cities the collection efficiency is below 50% [21].

On the basis of the available data, it is estimated that the nine major metropolitan centers in India are presently producing 23,000 tonnes of solid waste per day. As per recent estimates Bangalore generates about 3,600 tonnes per day and Table-6 provides comparative details about garbage generated and cleared in nine major Indian cities [22].

**Table-6: Urban Waste situation in some major Indian cities [23]**

| **Major Cities** | **Garbage Generated (tonnes/day)** | **Garbage Cleared (tonnes/day)** |
|---|---|---|
| Mumbai | 5800 | 5000 |
| Kolkata | 3500 | 3150 |
| Chennai | 2675 | 2140 |
| Delhi | 3880 | 2420 |
| Bangalore | 2130 | 1800 |

| | | |
|---|---|---|
| Lucknow | 1500 | 1000 |
| Patna | 1000 | 300 |
| Surat | 1250 | 1000 |
| Ahmedabad | 1500 | 1200 |

**4.3 Transfer & Transportation of MSW**

The MSW collected in pushcarts from lanes is transferred to a truck at a meeting point called a synchronization point [24]. The most common method for transfer in most of the areas is manual transfer from community bin to trucks by 2 to 3 workers [14]. In Ahmedabad, door-to-door collection method is adopted [18]. Here Waste collector knocks on each door or rings doorbell and waits for waste to be brought out by resident [25].

After the collection, the truck arrives at the designated point at a specified time and place. The waste is transported to the disposal site by means of a large capacity tipper truck, and in a few wards by a small capacity tipper truck or dumper placers. The truck is covered with a mesh and a polythene sheet to prevent scattering [26].

Collection and transportation activities constitute approximately 80–95% of the total budget of MSWM; hence, it forms a key component in determining the economics of the entire MSWM system [27].

**4.4 MSW Disposal and Treatment Process**

Waste treatment techniques seek to transform the waste into a form that is more manageable, reduce the volume or reduce the toxicity of the waste thus making the waste easier to dispose of. Treatment methods are selected based on the composition, quantity, and form of the waste material. Some waste treatment methods being used today include subjecting the waste to extremely high temperatures, dumping on land or land filling and use of biological processes to treat the waste [25].

The waste management sector follows a generally accepted hierarchy. The hierarchy started as the 'three Rs' — reduce, reuse, recycle — but now a fourth R is frequently added — recovery. The hierarchy responds to financial, environmental, social and management considerations. The hierarchy also encourages minimization of GHG emissions [28]. The waste hierarchy is shown in Fig-3.

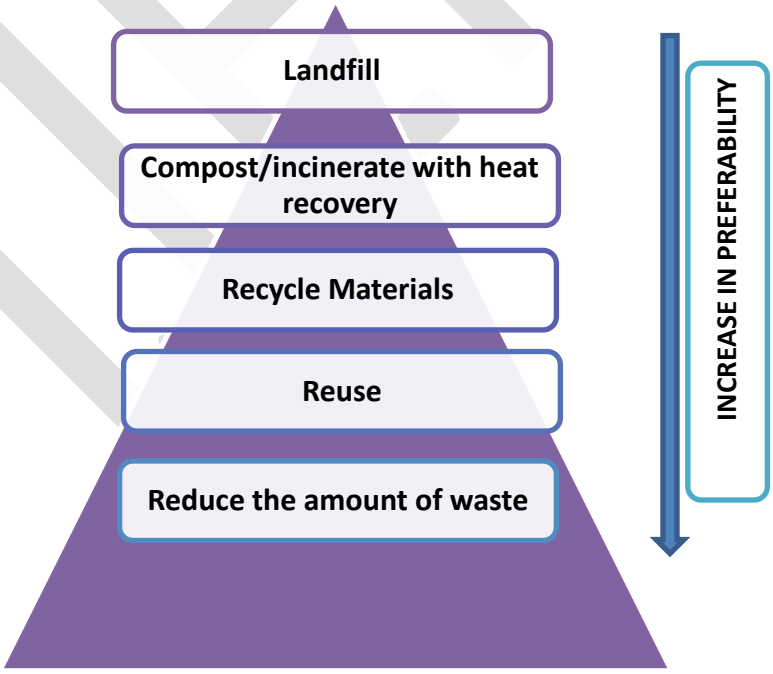



**Fig-3: A hierarchy of solid waste management**

The general principle of this hierarchy is to move the waste management down the hierarchy recycle, reuse and reduce. They are then followed by incineration and landfill, or other disposal options

### 4.4.1 Landfilling

A landfill is an area of land onto or into which waste is deposited. The aim is to avoid any contact between the waste and the surrounding environment, particularly the groundwater. More than 90% of MSW generated in India is directly disposed of on open land in an unsatisfactory manner, giving rise to serious environmental degradation, and numerous health and aesthetic hazards [29, 30]. These methods are not in accordance with the practices of sanitary landfilling. The pollution of groundwater, though largely unassessed, is definitely a threat posed by the dumping of wastes. Such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters [31].

In larger towns or cities like Delhi, the availability of land for waste disposal is very limited [31]. However, now landfilling is the most preferred method of disposal of solid wastes as it is an effective and low cost method of disposal [32] and, it appears that landfilling would continue to be the most widely adopted practice in India in the coming few years, during which certain improvements will have to be made to ensure the sanitary landfilling and not merely dumping of waste [33]. Sanitary landfill is a fully engineered disposal option, which avoids harmful effects of uncontrolled dumping by spreading, compacting and covering the wasteland that has been carefully engineered before use. Through proper site selection, preparation and management, operators can minimize the effects of leachates (polluted water which flows from a landfill) and gas production both in the present and in the future. In this process the waste is disposed and is covered with a layer of soil. The compact layer of soil restricts continued access to the waste by insects, rodents and other animals. It also isolates the refuse, minimizing the amount of surface water entering into and gas escaping from the waste [34].

### 4.4.2 Composting

Composting is a firm of recycling of MSW. The composting of waste can help decrease the volume of waste to 50-85% that must be sent to a landfill or combustor, thereby reducing disposal costs. At the same time, composting yields a valuable product that can be used by farmers, landscapers, horticulturists, government agencies, and property owners as a soil amendment or mulch. The compost product improves the condition of soil reduces erosion, and help suppress plant diseases [35].

This is a popular technique in Europe and Asia, where intense farming creates a demand for the compost [36].

**Table-7: Different Classes of Population**

| Population | Class | No of Cities |
|---|---|---|
| >10,00,000 and above (metro only) | | 35 |
| >1,00,000 and above | Class I | 393 |
| 50,000-99,999 | Class II | 401 |
| 20,000-49,999 | Class III | 1115 |
| 10,000-19,999 | Class IV | 1344 |
| 5,000-9,999 | Class V | 888 |
| >5,000 | Class VI | 191 |
| Unclassified | | 10 |
| | | 4377 |

*Source: CPCB, GOI (2004-2005) [37]*

In Class II, Class III and Class IV cities (shown in Table-) an urban agricultural set up exists and functions, where there is optimal use of municipal solid waste. The farmers buy the organic waste from the municipality at very low costs and use it as manure. There are

also companies that have taken over the responsibility segregating, decontaminating and composting MSW. This high quality compost is then sold to the farmers at a very high cost compared to the raw MSW. It has been observed that the farmers prefer the raw MSW to the processed high quality compost, because the latter is too expensive [24].

In 1974, GOI introduced modified scheme to revive MSW composting, particularly in cities with a population over 0.3 million. As far as large-scale composting is concerned, many mechanical compost plants with capacities ranging from 150 to 300 t/day were set up in the cities of Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur and Kanpur during 1975–1980 under the central scheme of MSW disposal. The composting was done successfully for many years up to 1980, but after that the compost from MSW was not used for soil enrichment due to many problems. Now, about 9% of MSW is treated by composting [7].

Few large-scale composting plants around India are running successfully. For e.g. composting plant in Hyderabad run by AP technology development and promotion center (intake of 200MT/day, composting plant in Vijaywada by Exel industries (intake of 125 MT/day), composting plant in Bangalore by Karnataka Compost Development Authority (KCDC)(intake of 300MT/day) and composting plant in Bangalore by Terra Firma Biotechnologies (100MT capacity). All these compost plants have a high demand for their products and want to increase their processing capacity to meet the huge demand. The awareness for organic manure is increasing rapidly in India that will in turn increase the demand for the manure produced from MSW [24].

### 4.4.3 Incineration

Incineration is an efficient way to reduce the waste volume and demand for landfill space. Incineration plants can be located close to the center of gravity of waste generation, thus reducing the cost of waste transportation. Using the ash from MSW incinerators for environmentally appropriate construction not only provides a low cost aggregate but further reduces the need for landfill capacity. However, Municipal solid waste (MSW) incineration plants tend to be among the most expensive solid waste management options, and they require highly skilled personnel and careful maintenance. For these reasons, incineration tends to be a good choice only when other, simpler, and less expensive choices are not available [38].

**Table-8: Municipal solid waste composition**

| Major cities | Compostables (%) | Recyclables (%) | C/N Ratio | HCV* (Kcal/Kg) | Moisture (%) |
|---|---|---|---|---|---|
| Imphal | 60.00 | 18.51 | 22.34 | 3766 | 40 |
| Jammu | 51.51 | 21.08 | 26.79 | 1782 | 40 |
| Kochi | 57.34 | 19.36 | 18.22 | 591 | 50 |
| Ranchi | 51.49 | 9.86 | 20.23 | 1060 | 49 |
| Coimbatore | 50.06 | 15.52 | 45.83 | 2381 | 54 |
| Amritsar | 65.02 | 13.94 | 30.69 | 1836 | 61 |
| Agra | 46.38 | 15.79 | 21.56 | 520 | 28 |
| Bhopal | 52.44 | 22.33 | 21.58 | 1421 | 43 |
| Jaipur | 45.50 | 12.10 | 43.29 | 834 | 21 |
| Kanpur | 47.52 | 11.93 | 27.64 | 1571 | 46 |
| Ahmedabad | 40.81 | 11.65 | 29.64 | 1180 | 32 |
| Hyderabad | 54.20 | 21.60 | 25.90 | 1969 | 46 |
| Bangalore | 51.84 | 22.43 | 35.12 | 2386 | 55 |

| | | | | | |
|---|---|---|---|---|---|
| Kolkata | 50.56 | 11.48 | 31.81 | 1201 | 46 |
| Delhi | 54.42 | 15.52 | 34.87 | 1802 | 49 |
| Greater Mumbai | 62.44 | 16.66 | 39.04 | 1786 | 54 |

*Source: CPCB, GOI (2004-2005) [9]*

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 [39]. however Small incinerators, in many cities in India, are being used for burning hospital waste [40].

### 4.4.4 Re-Use and Recycle of MSW

Re-use consists of the recovery of items to be used again, perhaps after some cleaning and refurbishing. Re-using materials and products saves energy and water, reduces pollution, and lessens society's consumption of natural resources compared with the use of single-application products and materials [1].

After the re-use of materials and products, recycling comes next in the integrated waste management hierarchy [1]. Recycling is the reprocessing of discarded materials into new useful product. The process of reusing of cans can save money. Recycling of paper will reduce of cutting of tress. Reuse of metals will reduce the mining activities. In India about 40-80% of plastic waste is recycled compared to 10-15% in the developed nations of the world. However the recovery rate of paper was 14% of the total paper consumption in 1991, while the global recovery rate was higher at 37% [34].

## V. REGULATORY & LEGAL FRAMEWORK FOR MSWM IN INDIA

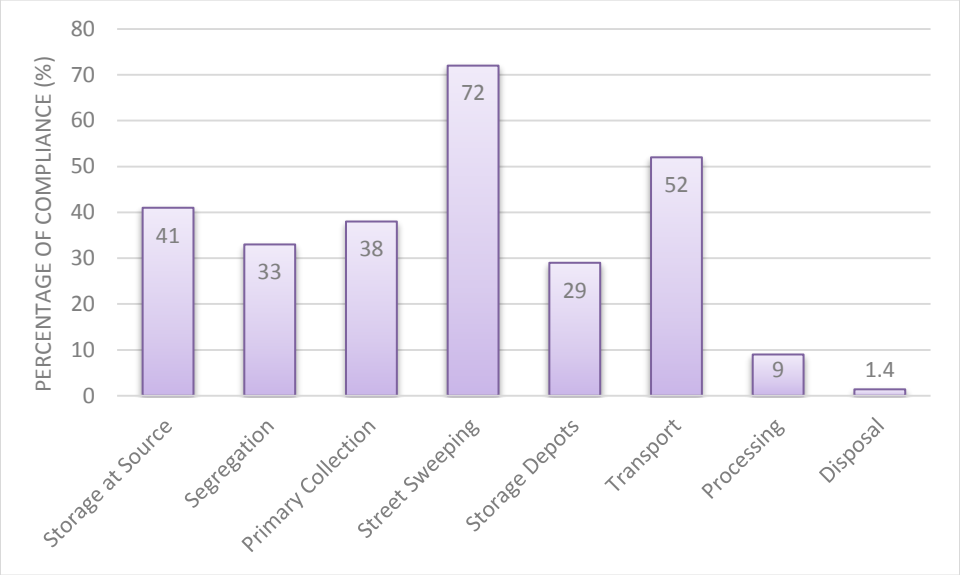
In September 2000, the Ministry of Environment and Forests issued the Municipal Solid Waste (Management and Handling) Rules 2000 under the Environment Protection Act 1986. The 2000 Rules lay down the steps to be taken by all municipal authorities to ensure management of solid waste according to best practice. Municipal authorities must meet the deadlines laid down in Schedule I of the rules and must follow the compliance criteria and procedure laid down in Schedule II. The deadline for implementing Schedule I of 2000 rules has already passed and the compliance is far from effective. Some cities and towns have not even started implementing measures that could lead to compliance with the rules (Table-9) [18].

**Table-9: The Four Steps of Schedule I of the 2000 Rules**

| **Steps** | **Completion date** |
|---|---|
| 1. Set up waste processing and disposal facilities | December 2003 or earlier |
| 2. Monitor the performance of processing and disposal facilities | Once every 6 months |
| 3. Improve existing landfill sites as per provision of the rules | December 2002 or earlier |
| 4. Identify landfill sites for future use and make sites ready for operation | December 2002 or earlier |

*Source: ministry of environment and forests 2000 [41]*

The status of the 2000 Rules is shown as percentage of compliance in Fig-4.




*Source: Asnani (2004a) [42]*

**Fig-4: Compliance with the 2000 Rules**

Some more rules, regulations and acts in India that are applicable regarding the management of MSW are explained below:

**1) The Water (Prevention and Control of Pollution) Act, 1974 (amended 1988)**

Under the provisions of this act, it is necessary that
a**)** for the establishment of a sanitary landfill site and compost plant consent from the approval of the concerned state pollution control board (SPCB) is essential, and
b) the leachate emitted from either a sanitary landfill site or a compost plant should cause no water pollution.

**2) The Water (Prevention and Control of Pollution) Cess Act, 1977 (amended 1992, 2003)**

Under its provision regarding MSWM, there would be levying and collection of cess on water consumed for the purpose of either sanitary land filling, composting or anaerobic digesters.

**3) The Air (Prevention and Control of Pollution) Act, 1981 (amended 1987)**

Under this act, the aspects to be considered regarding MSWM is the need for obtaining consent from the State Pollution Control Board (SPCB) for establishment of processing plants and disposal sites and the pollution caused by incineration plants, compost plants and landfill sites must be kept under its purview.

**4) The Environmental (Protection) Act, 1986 (amended 1991)**

Before starting any project in an area whether be it landfill site, composts plant or anaerobic digesters**,** an Environment Impact Assessment (EIA) report should be submitted first to the concerned government officials. Purportedly it is done to check any avoidable environmental disasters.

**5) Plastic Waste (Management and Handling) Rules, 2011**

The aspects in these rules regarding MSWM that have to be considered are that the Municipality would be responsible for engaging agencies or groups working in solid waste management and ensuring that open burning of plastic waste is not permitted.

## VI. CONCLUSION AND DISCUSSION

It can be very safely conclude that MSWM system in India is unsatisfactory. Although the economic condition of our country is poor, we have to handle the problem for the benefits of the whole public. To tackle the problems with maximum possible effectiveness, the

country should develop area-specific solutions to their problems in the management of MSW. Most importantly we cannot ignore the fact that the country is progressing towards developing sound institutions and proactive policies regarding MSW. The way forward is to build on the strengths and work on the weaknesses of the current system. This analysis suggests a number of priority actions to move towards an increasingly integrated and sustainable MSWM system in India:

- During segregation of MSW, the collection of organic waste, which comprises 60% wt. of MSW, for either composting or anaerobic digestion should be encouraged
- Increasing recycling rates and maximizing diversion of waste from landfill disposal, by introducing effective schemes to integrate both NGOs and the formal and local sectors into MSWM practices and to raise public awareness on the importance of recycling.
- Focusing on waste reduction and recovery.
- Integrating all stakeholders, and encouraging full community participation in the planning and implementation of MSWM practices.
- Developing an improved data collection and management system by the concerned authorities, so that future planning is based on sound data.
- Regular activities such as clean-up of the neighborhoods, schools, parks and roadsides can be effective in changing the ‘‘NIMBY’’ attitudes even among the poor communities.
- Drawing sponsors from Ministry of Environment and Forests (MoEF), Ministry of New and Renewable Energy (MNRE), Ministry of Health, NGOs and various private organizations.

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## REFERENCES:

[1] Medina, M., 2010. Solid Wastes, Poverty and the Environment in Developing Country Cities: Challenges and Opportunities. Working Paper No. 2010/23. ISBN 978-92-9230-258-0.

[2] Singh, G., 2014. Urbanization Trend and Pattern in India: Census 2011 and Beyond. Accessed from www.urbanecology.in on 05/05/2015. (URL: http://urbanecology.in/2014/10/10/urbanisation-trend-and-pattern-in-india-census-2011-and-beyond/).

[3] Johannesburg Summit, 2002. World Summit on Sustainable Development, 26 AUGUST–4 SEPTEMBER 2002. (URL: http://www.un.org/jsummit/html/brochure/brochure12.pdf).

[4] Pattnaik, S., Reddy, M.V., 2010. Assessment of municipal solid waste management in Puducherry (Pondicherry), India. Resources, Conservation and Recycling 54(2010) 512–520.

[5] Suez Lyonnaise des Eaux, 1998. Alternative Solutions for Water Supply and Sanitation in Areas with Limited Financial Resources. Nanterre: Suez Lyonnaise des Eaux.

[6] Joseph, K., Rajendiran, S., Senthilnathan, R., Rakesh, M., 2012. Integrated approach to solid waste management in Chennai: An Indian metro city. J Mater Cycles Waste Manag (2012) 14:75–84.

[7] Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C., 2008. Municipal solid waste management in Indian cities - A review. Waste Management 28 (2008) 459–467.

[8] What a Waste: Solid Waste Management in Asia, 1999. Urban Development Sector Unit East Asia and Pacific Region.

[9] Accessed from CPCB Website on 08/05/2015. (URL: http://cpcb.nic.in/wast/municipalwast/Waste_generation_Composition.pdf).

[10] Bhat, J. A., Choudhary, R. Challenges of Urbanisation in India: A Review of Solid Waste Management.

[11] GOI, 1995. Urban Solid Waste Management in India: Report of High Power Committee, Planning Commission and Government of India, Delhi.

[12] Hillebrand, E., 2009. Poverty, growth, and inequality over the next 50 years. FAO Expert Meeting on How to feed the World in 2050.

[13] Central Pollution Control Board (CPCB), 2000. Status of Municipal Solid Waste: Generation Collection Treatment and Disposal in Class I cities. The Ministry of Urban Development of India.

[14] The Expert Committee, 2000. Manual on Municipal Solid Waste Management (first edition). The Ministry of Urban Development of India.

[15] Agarwal, R. 2001. Urban waste: Status, trends and interventions. Personal Communication with Dr. A. K. Tripathy. The Ministry of Non-conventional Energy Sources of India.

[16] Bandyopadhyay, S. Smart Meters for Accounting Smart Solid Waste Management for Smart Cities in India.

[17] Kumar, R., 2012. Waste Management and Clean Mechanism Development. Accessed from www.booksie.com on 07/05/2015. (URL: http://www.booksie.com/other/article/rohit_kumar/waste-management-and-clean-development-machanism).

[18] Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S., Mani, S. Improving Municipal Solid Waste Management in India: A Sourcebook for Policymakers and Practitioners. ISBN: 978-0-8213-7361-3.

[19] IPE, 2004. Study of Management of Solid Waste in Indian Cities. Twelfth Finance Commission, Government of India.

[20] Kothari, R., Kumar, V., Panwar, N.L., Tyagi, V.V. Sustainable Bioenergy Production. ISBN-13: 978-1-4665-0552-0.

[21] Patil, A., 2011. Waste Management: Various Aspects in city of Pune, India. PLEA 2011 – 27th Conference on Passive and Low Energy Architecture, Belgium. ISBN: 978-2-87463-276-1.

[22] Gerlagh, R., Beukering, P.V., Verma, M, Yadav, P.P., Pandey, P., 1999. Integrated Modelling of Solid Waste in India.

[23] Accessed from (URL: http://wgbis.ces.iisc.ernet.in/energy/SWMTR/content2.html).

[24] Ramachandra, T.V., Bachamanda, S., 2007. Environmental audit of Municipal Solid Waste Management. Int. J. Environmental Technology and Management, Vol. 7, Nos. 3/4, 2007, pp 369-391.

[25] Solid waste management. Accessed from www.cyen.org on 07/05/2015. (URL: http://www.cyen.org/innovaeditor/assets/Solid%20waste%20management.pdf).

[26] Madhav, R., 2010. Untapped Potential: Securing livelihoods dependant on 'Waste': A Review of Law and Policy in India. (URL: http://wiego.org/sites/wiego.org/files/resources/files/wp_final_report.pdf).

[27] Chatri, A.K., Aziz, A., 2012. Public Private Partnerships in Municipal Solid Waste Management: Potential and Strategies.

[28] Hoornweg, D., Bhada-Tata, P., 2012. What a Waste: A Global Review of Solid Waste Management.

[29] Das, D., Srinivasu, M., Bandyopadhyay, M., 1998. Solid state acidification of vegetable waste. Ind. J. Environ. Health, 40 (4): 333-342.

[30] Ambulkar, A. R., Shekdar, A. V., 2004. Prospects of biomethanation technology in the Indian context: a pragmatic approach. Resources, Conservation and Recycling 40, Issue 2, 111-128.

[31] Kaushal, R.K., Varghese, G.K., Chabukdhara, M., 2012. Municipal Solid Waste Management in India-Current State and Future Challenges: A Review. Rajendra Kumar Kaushal et al. / International Journal of Engineering Science and Technology (IJEST).

[32] Nissim, I., Shohat, T., Inbar, Y., 2005. From dumping to sanitary landfills – solid waste management in Israel. Waste Management 25, Issue 3, 323-327.

[33] Ramteke, D.S. Reclamation & Remediation of Solid Waste through Bio-chemical process. ISBN: 978-90-481-3677-3 (HB).

[34] Rajput, R., Prasad, G., Chopra, A.K., 2009. Scenario of solid waste management in present Indian context. Caspian J. Env. Sci. 2009, Vol. 7 No.1 pp. 45-53.

[35] Composting of Yard Trimmings and Municipal Solid Waste, 1994. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response.

[36] Schneider, W. J., 1970. Hydrologic Implications of Solid-Waste Disposal. U.S. Geological Survey Circular 601-F.

[37] Accessed from CPCB Website on 08/05/2015. (URL: http://cpcb.nic.in/Local_Bodies.php).

[38] Decision Makers' Guide to Municipal Solid Waste Incineration, 1999. The World Bank Washington, D.C.

[39] Kansal, A., 2002. Solid waste management strategies for India. Indian Journal of Environmental Protection 22 (4), 444–448.

[40] Lal, A.K., 1996. Environmental status of Delhi. Indian Journal of Environmental Protection 16 (1), 1–11.

[41] Government of India, 2000. The Municipal Solid Wastes (Management and Handling) Rules, 2000. Ministry of Environment and Forests of India.

[42] Asnani, P. U. 2004a. Status of Compliance of Municipal Solid Waste (Management and Handling) Rules 2000 in 127 Class 1 Cities in India as on 1-4-04. Paper presented at the National Training Programme on Design, Construction, and Operation of Sanitary Landfills, jointly organized by the Government of India, the Central Pollution Control Board, the United States–Asia Environmental Program, and the Water and Sanitation Programme of the World Bank, at Panaji, Goa, India