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# CHALLENGES AND OPPORTUNITIES ASSOCIATED WITH WASTE MANAGEMENT IN INDIA

**Kailash Bharti Goswami***

**Abstract:**

India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal. Current systems in India cannot cope with the volumes of waste generated by an increasing urban population, and these impacts on the environment and public health. The challenges and barriers are significant, but so are the opportunities. A priority is to move from reliance on waste dumps that offer no environmental protection, to waste management systems that retain useful resources within the economy. Waste segregation at source and use of specialized waste processing facilities to separate recyclable materials has a key role. Disposal of residual waste after extraction of material resources needs engineered landfill sites and/or investment in waste-to-energy facilities. The potential for energy generation from landfill via methane extraction or thermal treatment is a major opportunity, but a key barrier is the shortage of qualified engineers and environmental professionals with the experience to deliver improved waste management systems in India.

**Keywords: Waste Management, Sustainable Development, Population Growth, Resource, Recovery**

* **Research Scholar, D.S.B.Campus, Kumaun University Nainital,Uttarakhand India**

## 1. Introduction

India is rapidly shifting from agricultural-based nation to industrial and services-oriented country. About 31.2% population is now living in urban areas. Over 377 million urban people are living in 7,935 towns/cities. India is a vast country divided into 29 States and 7 Union Territories (UTs). There are three mega cities—Greater Mumbai, Delhi, and Kolkata—having population of more than 10 million, 53 cities have more than 1 million population, and 415 cities having population 100,000 or more. Solid waste management (SWM) is a major problem for many urban local bodies (ULBs) in India, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste (MSW) generation per person [1]. Effective SWM is a major challenge in cities with high population density. Achieving sustainable development within a country experiencing rapid population growth and improvements in living standards is made more difficult in India because it is a diverse country with many different religious groups, cultures and traditions. Despite significant development in social, economic and environmental areas, SWM systems in India have remained relatively unchanged. The informal sector has a key role in extracting value from waste, with approximately 90% of residual waste currently dumped rather than properly landfilled [2]. There is an urgent need to move to more sustainable SWM, and this requires new management systems and waste management facilities. Current SWM systems are inefficient, with waste having a negative impact on public health, the environment and the economy [3]. The Ministry of Environment and Forests (MoEF) [4] introduced the waste Management and Handling Rules in India, although compliance is variable and limited.

## 2. Research Methodology

This paper is the outcome of a secondary data on waste generation and waste management with special reference to Indian context. To complete this, annual reports, various books, journals and periodicals have been consulted, several reports on this particular area have been considered, and internet searching has been done.

## 3. Waste Generation in India

India is experiencing rapid urbanization while remaining a country with physical, climatic, geographical, ecological, social, cultural and linguistic diversity. The population of India was

1252 million in 2013, compared with 1028 million in 2001. Population growth is a major contributor to increasing MSW in India.

**Table 1: Population Growth in India Between 1911 and 2011**

| Census Year | Population $\times 10^6$ | Decadal Growth $\times 10^6$ | Average Annual Exponential Growth Rate (%) | Progressive Growth Rate Compared With 1911 (%) |
|---|---|---|---|---|
| **1911** | 252 | 13.7 | 0.56 | 5.75 |
| **1921** | 251.3 | -0.8 | -0.03 | 5.42 |
| **1931** | 278.9 | 27.6 | 1.04 | 17.02 |
| **1941** | 318.6 | 39.7 | 1.33 | 33.67 |
| **1951** | 361.1 | 42.4 | 1.25 | 51.47 |
| **1961** | 439.2 | 78.1 | 1.96 | 84.25 |
| **1971** | 548.1 | 108.9 | 2.2 | 129.94 |
| **1981** | 683.3 | 135.1 | 2.22 | 186.64 |
| **1991** | 846.4 | 163.1 | 2.16 | 255.05 |
| **2001** | 1028.7 | 182.3 | 1.98 | 331.52 |
| **2011** | | | | |

**Source: Census of India, 2011 and CPCB report 2014 [5]**

### 3.1 Growth of Mega Cities in India

Mega cities are a relatively recent phenomenon, associated with globalization of the economy, culture and technology. Mega cities in India include Ahmedabad (6.3million), Hyderabad (7.7million), Bangalore (8.4million), Chennai (8.6million), Kolkata (14.1million), Delhi (16.3million) and Greater Mumbai (18.4 million). These have dynamic economic growth and high waste generation per capita, as shown in table 2.

**Table 2: Major Cities in India and Per Capita Waste Generation**

| City | Population $\times 10^6$ | Waste Generated in Tones Per Day | Waste Generation (kg Per Capita Per Day) |
|---|---|---|---|
| **Ahmadabad** | 6.3 | 2700 | 0.42 |
| **Hyderabad** | 7.7 | 4300 | 0.55 |
| **Bangalore** | 8.4 | 3900 | 0.46 |
| **Chennai** | 8.6 | 4800 | 0.55 |
| **Kolkata** | 14.1 | 4170 | 0.29 |
| **Delhi** | 16.3 | 6420 | 0.39 |
| **Mumbai** | 18.4 | 6890 | 0.37 |

**Source: Census of India 2011 & CPCB Report 2014 [5]**

### 2.2 Infrastructure development for public health and protection of the environment

Improvements in civil infrastructure are required for India to become a world leading economy. Developing high-quality infrastructure that meets the needs of the people and protects the environment is fundamental to achieving effective economic growth [6]. Waste management infrastructure has an important role in delivering sustainable development. Rapid population growth in India has led to depletion of natural resources. Wastes are potential resources and effective waste management with resource extraction is fundamental to effective SWM. Value extraction from waste can be materials, energy or nutrients, and this can provide a livelihood for many people. The transition from wastes to resources can only be achieved through investment in SWM as this depends on a coordinated set of actions to develop markets and maximize recovery of reusable/recyclable materials [7]. Materials, energy and nutrient recovery must be the aim of future SWM infrastructure development in India. Resources can be recovered from wastes using existing technologies and India has an extremely effective recycling tradition. The 'scrap dealer' systems produce recycled materials through an extensive and well-coordinated network across the country.

### 2.3 Statistics on waste generation and waste characterization data

Estimating the quantity and characteristics of MSW in India and forecasting future waste generation is fundamental to successful waste management planning . The quantity of MSW generated depends on living standards, the extent and type of commercial activity, eating habits and season. India generates approximately 133760 tonnes of MSW per day, of which approximately 91152 tonnes is collected &

| Waste Generation Per Capita In Indian Cities | |
|---|---|
| Population | Waste Management Rate (kg Per Capita Per Day) |
| Cities with a Population of < 0.1 Million | 0.17-0.54 |
| Cities with a Population of 0.1-0.5 Million | 0.22-0.59 |
| Cities with a Population of 1-2 Million | 0.19-0.53 |
| Cities with a Population of > 2 Million | 0.22-0.62 |
| **Source: CPCB Report 2014 [8]** | |

approximately 25884 tonnes is treated. MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities [8]. Waste generation rate depends on factors such as population density, economic status, level of commercial activity, culture and city/region. MSW generation in different states, indicating high waste generation in Maharashtra (115364–19204 tonnes per day), Uttar Pradesh, Tamil Nadu, West Bengal (11523–15363 tonnes per day), Andhra Pradesh, Kerala (7683–11522 tonnes per day) and Madhya Pradesh, Rajasthan, Gujarat, Karnataka and Mizoram (3842–7662tonnes per day). Lower waste generation occurs in Jammu and Kashmir, Uttarakhand, Bihar, Jharkhand, Chhattisgarh, Orissa, Goa, Assam, Arunachal Pradesh, Meghalaya, Tripura, Nagaland and Manipur (less than 3841 tonnes per day) [9].

### 2.4 Waste characterization data

The local economy impacts on waste composition, as high-income groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Changes in

waste composition can have a significant impact on waste management practices. MSW may also contain hazardous wastes such as pesticides, paints, used medicine and batteries. Compostable organics include fruits, vegetables and food waste. Healthcare waste contains disposable syringes, sanitary materials and blood containing textiles and is governed by the Biomedical Waste (Management and Handling) Rules 1998 and the Amended Rules, 2003, and should not be mixed with MSW [10]. The average composition of MSW produced by Indian cities is approximately 41 wt.% organic, approximately 40 wt.% inert, with approximately 19 wt.% potentially recyclable materials [11]. Most organic waste is generated from households, and inert waste is generated from construction, demolition and road sweeping.

### 2.5 Predictions on future waste growth

World waste production is expected to be approximately 27 billion tonnes per year by 2050, one-third of which will come from Asia, with major contributions from China and India [12]. Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in1999. The problems associated with waste become more acute as the size of communities increase and this provides opportunities for decentralized waste management by self-help groups and NGOs. The waste produced in urban areas of India is approximately 170000 tonnes per day, equivalent to about 62 million tonnes per year, and this is expected to increase by 5% per year owing to increases in population and changing lifestyles [13].

**Predicted Population Growth & Overall Impact on Waste Generation**

| Year | Population ×106 | Per Capita Waste Generation (kg Per Day) | Total Waste Generation (×103 Tonnes Per Day) |
|---|---|---|---|
| 2021 | 342.8 | 0.568 | 71.15 |
| 2031 | 451.8 | 0.649 | 107.01 |
| 2036 | 518.6 | 0.693 | 131.24 |
| 2041 | 595.4 | 0.741 | 160.96 |

Source: R K Amepu [14]

By 2041, waste generation is predicted to be 161 million tonnes, a five fold increase in four decades.

## 3. Solid waste management practices and challenges in India

In India, MSWM is governed by MSWR. However, majority of ULBs do not have appropriate action plans for execution and enactment of the MSWR. Unfortunately, no city in India can claim 100% segregation of waste at dwelling unit and on an average only 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment. Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps [8].

### 3.1 Key waste management legislations in India

The MoEF issued MSW (Management and Handling) Rules 2000 to ensure proper waste management in India and new updated draft rules have recently been published. Municipal authorities are responsible for implementing these rules and developing infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW. Chandigarh is the first city to develop SWM in a planned way and has improved waste management compared with other Indian cities [15].

### 3.2 Segregation

There is no organized and scientifically planned segregation of MSW either at household level or at community bin. Sorting of waste, is mostly accomplished by unorganized sector and seldom practiced by waste producers. Segregation and sorting takes places under very unsafe and hazardous conditions and the effectiveness of segregation is reasonably low as unorganized sector segregates only valuable discarded constituents from waste stream which can guarantee them comparatively higher economic return in the recycling market. On a number of occasions, due to improper handling the segregated constituents got mixed up again during transportation and disposal. Lack of segregation deprive proper scientific disposal of waste [16].

### 3.2. Collection

Waste produced by houses is usually transferred into communal bins that are fabricated from metal, made from concrete or in combination of both. Street sweepings also find its way to community bins. These community waste bins are also used by other essential commercial sectors in the vicinity of disposal bins along with household waste except where some commercial complexes or industrial units engage municipal authorities for transfer of their waste to disposal site by paying some amount.

### 3.3. Reuse/recycle

This entails activities like collecting those materials from the waste, which could be gainfully retrieved and utilized for making new products. Since unsegregated waste is dumped at community bins, its optimal recycling is not possible. However, rag-pickers usually sorted out and took and sell recyclable material like plastics, glass, etc. In Pondicherry, almost all recyclable material is sorted out by rag-pickers and absorbed in material stream through recycling.

### 3.3 Transportation

Modes of transportation for MSWM practised in India are bullock carts, hand rickshaws, compactors, trucks, tractor, trailers, and dumpers. In smaller towns, trucks having 5–9 ton capacity are used without adequate cover system. Stationary compactors, mobile compactors/closed tempos, and tarpaulin-covered vehicles are used in the transportation of MSW and about 65, 15, and 20% of waste is transported through these compacters, respectively. The maintenance of vehicles used in for transportation of waste is usually done in workshop run by ULBs but most of these workshops can do minor repairs only. No wonder, in the event of breakdown of these vehicles, the overall collection, transportation, and disposal efficiency reduces drastically. Only few transfer stations can be found in some metropolitan e.g. Mumbai.

### 3.4 Disposal

In India, almost every city, town, or village adopted unscientific disposal of MSW. The existing practice and technology availability for MSWM is traditional. Waste collection, storage and

transport are essential elements of any SWM system and can be major challenges in cities. Uncontrolled open dumping is a common feature in almost all cities. More than 90% of waste in India is believed to be dumped in an unsatisfactory manner. It is estimated that approximately 1400 $km^2$ was occupied by waste dumps in 1997 and this is increase to 1800 $km^2$ in 2014 and expected an increase in the future [23]. The following disposal practices are in use in hierarchy:

### 3.5.1. Open dumping

In India, MSW generated is usually directly disposed on low lying area in routine way violating the practices of sanitary landfilling. Almost no ULBs have adequate sanitary landfilling facility and MSW is dumped in the outskirts of town along the roads. Unscientific dumping is prone to flooding and major source of surface water contamination during monsoon and ground water contamination due to percolation of leachate.

### 3.5.2. Landfilling

Landfilling would continue to be extensively accepted practice in India, though metropolitan centers like Delhi, Mumbai, Kolkata and Chennai have limited availability of land for waste disposal and designated landfill sites are running beyond their capacity. The development of new sanitary landfills/expansion of existing landfill are reported in the states such as Andhra Pradesh (Vijianagaram), Delhi (Bhalswa, Okhla and Ghazipur), Goa, Gujarat (8 sites), Haryana (Sirsaand Ambala), Karnataka (12 sites.), Madhya Pradesh (Gwalior and Indore), Maharashtra (Nashik, Sonpeth, Ambad, Pune, Navapur and Navi Mumbai), Punjab (Adampur), Rajasthan (Jodhpur), and West Bengal (17 sites) [24]. According to CPCB, 2013 report, till date, India has 59 constructed landfill sites and 376 are under planning and implementation stage. Apart from this, 1305 sites have been identified for future use.

### 3.5.3. Biological treatment of organic waste

The waste generated in India has produced more organic content nearly 50% as compared to 30% generated by developed countries, Following composting methods are commonly adopted in India:

**3.5.3.1. Aerobic composting**

**3.5.3.2. Vermi-composting**

**3.5.3.3. Anaerobic digestion**

**3.5.5.4. Thermal treatment**

| Number of Compositing/ Vermi-Compositing Plants in Some States | |
|---|---|
| **States** | **Number of Plants** |
| **Maharashtra** | 125 |
| **Gujarat** | 86 |
| **Kerala** | 29 |
| **Chhattisgarh** | 15 |
| **Delhi(UT)** | 5 |
| **Uttarakhand** | 3 |
| **Punjab** | 2 |
| **Harayana** | 2 |
| **Source: CPCB report, 2014 [8]** | |

| Number of Energy Recovery Plants In some States | |
|---|---|
| **State** | **Number of RDF plants, Waste to Energy Plants (PP), Biogas (BG)** |
| **Andhra Pradesh** | 3-RDF, 4-PP |
| **Delhi(UT)** | 1-RDF, 1-PP |
| **Chhattisgarh** | 1-RDF |
| **Maharashtra** | 19-BG |
| **Gujarat** | 2-RDF |
| **Kerala** | 2-BG |
| **Source: CPCB report, 2014 [8]** | |

## 4. Challenges

- **Awareness to enhance segregation:**

Ecological awareness and citizen participation to segregate waste at source, door-to-door collection, and disposal in appropriate collecting bin is imperative. The awareness plays an important role in MSWM and augments the efficiency of waste management stream. It is the most critical phase in the whole process of MSWM, which helps in handling solid waste leading to ultimate success. However, in India, the present scenario reveals that there is almost no segregation of garbage at source which leads to various environmental problems and it becomes very difficult to segregate waste at transfer station or in landfill or treatment site. Also, due to lack of coordination among the residents and lack of planned cities in India, the residents throw garbage improperly. Apart from this, the community bins are not located in the close vicinity and the number of ULBs employees is not adequate as per population residing in that area.

- **Characterization of municipal solid waste:**

India is a vast country divided into different climatic zone, different food habits, and different living standard thereby producing waste of different types. Until date, no comprehensive studies have been conducted to cover almost all cities and towns of India to characterize the waste generated and disposed on landfill. The policy-makers rely on the limited source of information available from few places thereby are unable to provide appropriate solutions for the kind of waste produced for a particular region.

- **Urbanization and lack of appropriate level funding:**

With the population growth, challenge to provide adequate infrastructure in urban area and new landfill site selection is important. Most of the landfill sites are running beyond their capacity in metropolitan cities. Inadequate financial support to cater to waste management problem aggravates it. Due to financial crunch ULBs do not have adequate infrastructure to provide suitable solutions.

- **Implementation of rules at ground level:**

ULBs are not implementing MSWR adequately as revealed by various government reports; thus it is difficult to manage the MSW properly. There is a need to create dedicated group of officers and skilled staff for ULBs with specialization in MSWM. Adequate training and hands-on experiments would enable them to identify bottlenecks at implementation level and take appropriate action.

- **Lack of coordination among Centre and State:**

There is less dialogue between Central and State government. Delay in submission of information from State to Central delays appropriate level implementation at ground level. Such lack of coordination for specific action plan and poor strategy at implementation level by ULBs are main hindrance.

- **Failure of waste-to-energy projects:**

India is still struggling to make waste-to-energy project a success story. There is a need to import economically feasible and proven technologies. Apart from this, suitably characterized and segregated waste needs to be provided to waste-to-energy plants as per its requirement.

- **Involvement of organized sector:**

For improving MSW collection efficiency and source segregations, rag-pickers can be engaged through organized sector. However, due to lack of recycling industries and acceptance of society this vast potential has been ignored.

## 5. Conclusion

Population growth and particularly the development of megacities is making SWM in India a major problem. The current situation is that India relies on in adequate waste infrastructure, the in formal sector and waste dumping. There are major issues associated with public participation in waste management and there is generally a lack of responsibility towards waste in the community. There is a need to cultivate community awareness and change the attitude of people towards waste, as this is fundamental to developing proper and sustainable waste management systems. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities. India faces challenges related to waste policy, waste technology selection and the availability of appropriately trained people in the waste management sector. Until these fundamental requirements are met, India will continue to suffer from poor waste management and the associated impacts on public health and the environment.

## 6. Suggestions

Following are various suggestions that evolve from this study to improve the existing MSWM practices in India:

1. The community should pay to augment inadequate resources for MSWM of municipal bodies. Community participation in SWM is the key to sustain a project related to management of solid waste. Till date no such tax has been levied for SWM.
2. The people should be educated to realize the importance of source segregation at generation point as biodegradables, inert and recyclable material for proper waste management.
3. Viable decentralized composting plants should be installed to reduce the load on ULBs for collection and transportation of MSW, which subsequently culminates in reduction of the pressure exerted on the landfills.
4. In most parts of India, sweeper and rag-pickers are still considered inferior class of citizens despite several laws in place to bring dignity to their profession. To change people's views and perspective, awareness regarding this important service to community should be initiated and manpower engaged in such activities should be named as Green brigade/Crew, and so on.
5. Characterization of waste at collection and also at disposal point should be made and be available in public domain. Government should take initiative to encourage Universities, technical Institution to take up waste management in its curriculum. Assistance of academic institutions should be solicited in characterization of waste in their vicinity.

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