ISSN: 2633-4828 Vol. 6 No.1, January, 2024

*International Journal of Applied Engineering & Technology*

# NAVIGATING MUNICIPAL SOLID WASTE MANAGEMENT IN INDIAN CITIES: STATUS, CHALLENGES, AND SUSTAINABLE SOLUTION

**Sanjeev Kumar[1]*, Ran Vijay Singh[2] and Kunal Kumar[3]**

[1]Ph.D Scholar, B.I.T. Sindri, Jharkhand University of Technology (JUT) and Assistant Manager Environment, Coal India Limited

[2]Professor, Department of Civil Engineering, B.I.T Sindri, JUT

[3]Associate Professor, Department of Chemistry, B.I.T Sindri, JUT

[1]sanjeevamarsingh@gmail.com and [2]rvsingh.civil@bitsindri.ac.in

## ABSTRACT

*In recent years have seen exponential population growth, high urban density, cultural diversity, altered eating habits, and lifestyles all contribute to India's already severe Municipal Solid Waste Management (MSWM) crisis. Because of this, municipalities have faced several additional challenges related to solid waste management, treatment, and collection. This study examines SWM in India from every angle, including its present condition, its problems, and possible remedies using MSWM. Urban local governments are ill-equipped to handle the ever-increasing amounts of solid waste produced by rapidly expanding populations, infrastructure, and people's lifestyle choices, making MSWM a more pressing issue in metropolitan areas. Inadequate prospective methods, social taboo, improper assessment, unforeseen fiscal waste, citizen attitudes, inadequate source-side waste segregation, and poor government policy execution are other difficulties that impact the MSWM system. Consequently, MSWM has become a significant burden owing to health and environmental concerns as well as the enormous volumes of rubbish created. Consequently, this review article's goal is to zero in on various problems and obstacles associated with SWM and possible MSWM solutions in India.*

*Keywords: Municipal Solid Waste, Sustainable Management, Challenges, Environmental Sustainability*

## 1. INTRODUCTION

Both developing nations and industrialised countries have a difficult challenge when it comes to the “Municipal Solid Waste Management” (MSWM). The amount of municipal solid garbage has risen because of rapid urbanisation and industrialization, as well as a great growth in economic status and activities. Additionally, the contents of this waste have been transformed. A grave situation has arisen as a consequence of the municipalities, particularly those in developing nations, failing to demonstrate sufficient motivation and failing to handle their affairs in an appropriate manner. In developing nations, the amount of solid waste that is generated is lower than in industrialised countries; yet, the disposal of solid waste is inefficient, which thus results in contamination of the water supply, the land, and the air. There are many different sorts of environmental issues that arise in metropolitan areas as a consequence of a lack of basic knowledge of solid waste management. Additional areas of concern in these regions include the contamination of the water and soil, as well as the pollution of the air and greenhouse gases, among other related issues.

Currently, India is transitioning from a nation that is mostly dependent on agriculture to a nation that is more focused on industry and services. There is around 31.2% of the people living in urban areas at the moment. In 7,935 towns and cities, there are more than 377 million people living in urban areas. A total of 29 states and seven union territories (UTs) make up the country of India. Thirty-three cities, including Kolkata, Delhi, and Mumbai, each have populations of more over ten million people. In addition, there are 53 cities with populations of more than one million people, and there are 415 cities with populations of 100,000 or more. The pollution levels of cities with populations of more over 10 million people are taken into consideration when determining the state capitals, Union Territories, and other economic and industrial-oriented centres. In India, there are many diverse geographical and climatic zones, and the people who live in these locations have varied patterns of waste creation and use according to their lifestyles. Nevertheless, as of this moment, there have been no concrete actions done to investigate the patterns of waste creation that are peculiar to these big metropolises in terms of both geography

and location. Based on the study that was carried out by the "National Engineering and Environmental Research Institute" (NEERI) in Nagpur and the "Central Pollution Control Board" (CPCB) in New Delhi, researchers are forced to rely on the little data that is available to them.

Municipal solid waste management plays an important part in the pursuit of research in developed nations, and the economic and technical improvements that have occurred in recent years have prompted stakeholders to become more receptive to this kind of management. Developing nations are experiencing fast population increase, quickly changing patterns of solid waste creation and classification, expanding urbanisation, and increasing industry. all of these factors are occurring simultaneously.

In order to address all of the problems that are associated with solid waste, MSWM encompasses a variety of tasks, including administrative, engineering, legal, and financial functions. Activities related with "Municipal Solid Waste Management" (MSWM) typically include generation, reduction, reuse, recycling, handling, segregation, collection, transfer and transport, transformation, and disposal. These activities are involved from the point of generation to the point of ultimate disposal. An efficient system for the management of solid waste may be built by taking into account the circumstances that are unique to the location. Additionally, legislative efforts and the appropriate execution of those efforts play a significant part in the efficient management of solid waste, which includes the scientific disposal of collected solid waste. "The adoption of successful practices of safe treatments, harmless manufacturing processes, and ways for transforming solid waste into valuable resources may, on the other hand, be rewarded with financial incentives. According to the findings of a number of studies, the reuse of solid waste is not only a feasible alternative to the management of municipal solid trash, but it is also recommended from an economic, social, and environmental standpoint. In metropolitan India, one of the most serious difficulties is the absence of segregation of municipal solid waste, as well as the absence of effective disposal of building and demolition debris, plastic wastes, commercial and industrial rejects, and electronic trash. The purpose of this article is to provide an overview of the current state of "Municipal Solid Waste Management" (MSWM), as well as the challenges that are connected with the system, and to also propose some of the most effective techniques that may be implemented in Indian cities.

## 2. SOLID WASTE GENERATION IN INDIA

When emerging nations are contrasted to developed ones, the fast rise in population in urban centres is more obvious in developing countries. With a current population of 1.36 billion people, India is the second most populous nation in the world right now. From 1991 to 2021, the percentage of the population that resided in urban areas expanded dramatically, going from 18 to 31.2% accordingly.

Municipal solid waste has become a serious problem as a result of rising urbanisation and an increased population growth rate, which are the primary causes for the problem. Table 1 displays the trash production rate per capita and its rise over the course of a decade, based on the population size per capita.

**Table 1:** Waste generation per capita rate.

| Population size | Waste generation (kg/capita/day) |
|---|---|
| >2000000 | 0.55 |
| 1000000–2000000 | 0.46 |
| 500000–1000000 | 0.48 |
| 100000–500000 | 0.46 |
| <100000 | - |

Also, it is estimated that the population of India will reach around 1,823 million by the year 2051, and the creation of municipal solid trash would be approximately 300 million tonnes per year." This will need the use of approximately 1,450 km squared of land in order to dispose of solid garbage in a methodical way. However, these forecasts are on the cautious side, since they assume an annual growth rate of around 1.33 percent per capita for

municipal solid waste output. Consequently, with an annual growth rate of around 5% per capita in the creation of solid waste, the amount of land that is needed for the disposal of solid waste might be multiplied by a great deal.

It was reported in the Planning Commission Report that there are currently 377 million people living in urban areas, and these urban areas generate 62 million tonnes of municipal solid waste annually. It is anticipated that by the year 2013, these urban areas will generate 165 million tonnes of solid waste annually, and it is possible that this number could reach 436 million tonnes of solid waste in the year 2050. It is necessary to have a landfill site that is 23.5x107 cubic metres in order to contain the solid waste that would be created by the year 2031. In terms of quantity, it would take around 1,175 hectares of land per year. With a waste production rate of 0.45 kilogrammes per person per day, the space that would be needed between the years 2031 and 2050 would be 43,000 hectares of landfills stacked at a height of 20 metres. The availability of primary data on trash production per capita, insufficient data on the nature of solid waste, and the effect of informal sectors have all contributed to the fact that different publications have provided a variety of estimates and forecasts. Because of this, it is very challenging to forecast the amount of land that will be needed and to recommend suitable treatment methods. It was discovered in the survey report that was conducted by the "Central Institute of Plastics Engineering and Technology" (CIPET) for 59 cities (35 metro cities and 24 state capitals) that over the period of 2019-2020, these cities and towns produced a total of 50,592 TPD of municipal solid waste.

According to the findings of a number of research projects, smaller municipalities have paid more attention to and performed more successfully in terms of the creation rate of municipal solid waste. Table 2 presents a comparison of the amounts of municipal solid waste (MSW) produced by a particular set of states in India over the years 2019 and 2021. Figure 1 depicts the comparative situation of the creation of "Municipal Solid Waste" (MSW) per capita for the years 2019 and 2021 with regard to a selection of states in India.

The composition of municipal solid waste is impacted by a wide range of variables, some of which include eating habits, cultural practices, climatic considerations, and income generation by businesses, amongst others. "Paper, textiles, food waste, straw, and yard trash are the primary components of municipal solid waste (MSW) in India. Other components include partially degradable waste wood (disposable napkins and sludge, sanitary residues), and non-degradable products such as leather, plastics, rubbers, metals, glass, ash from fuel burning (coal, briquettes or woods), dust, and electronic waste. Figure 2. A C/N ratio of between 800 and 1000 kcal/kg is estimated to be present in municipal solid waste. Food waste is packed with moisture, which is a significant contributor to municipal solid waste. Because high-income groups consume more paper, glass, metals, plastics, and textiles than low-income groups do, the amount of paper, glass, metals, plastics, and textiles produced by high-income groups is greater than that of low-income ones.

**Table 2:** Statistics of MSW generated in different states in India

| No. | Indian States | Municipal Solid Waste (TPD) (2019-2021) |
|---|---|---|
| **1** | Andhra Pradesh | 6898 |
| **2** | Assam | 1199 |
| **3** | Delhi | 10990 |
| **4** | Gujarat | 10373 |
| **5** | Karnataka | 11085 |
| **6** | Kerala | 3543 |
| **7** | Madhya Pradesh | 8022 |
| **8** | Maharashtra | 22632 |
| **9** | Manipur | 283 |
| **10** | Meghalaya | 107 |
| **11** | Orissa | 2132 |
| **12** | Punjab | 4338 |
| **13** | Puducherry | 504 |

| | | |
|---|---|---|
| **14** | Rajasthan | 6897 |
| **15** | Tamil Nadu | 13422 |
| **16** | Tripura | 334 |
| **17** | Uttar Pradesh | 14710 |
| **18** | West Bengal | 13709 |

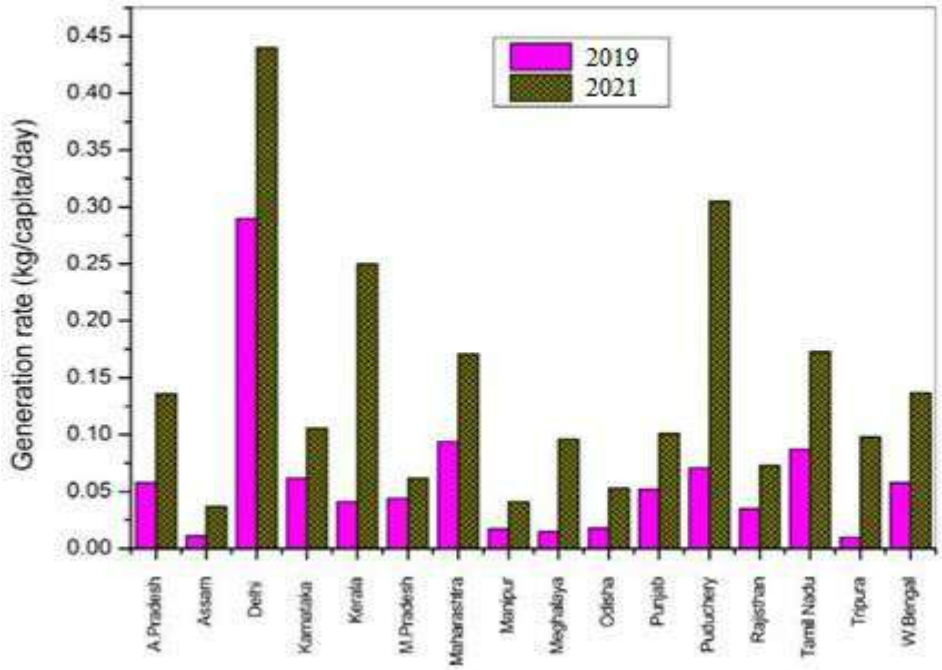


**Figure 1:** Per capita generation of MSW in selected Indian states in 2019 and 2021

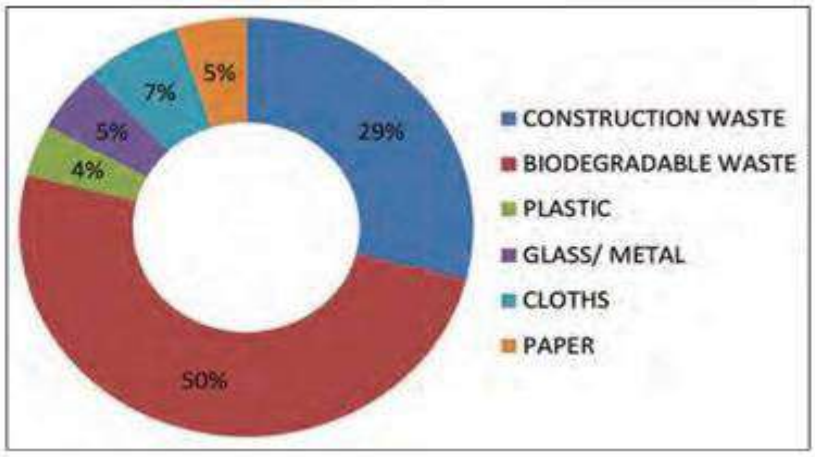


**Figure 2:** Composition of MSW in India

## 3. SOLID WASTE MANAGEMENT

In addition to being the leader of the municipality, the Commissioner is accountable for carrying out responsibilities and fulfilling activities. Currently, the Municipality, which is the agency that is entrusted with the responsibility of disposing of solid waste, is engaged in a variety of activities in order to provide an efficient system for the management of solid waste. These activities include incorporating a number of different approaches, such as the participation of citizens, investments in infrastructure and technology, and monitoring the

various systems that are time managing the existing mix of actions and techniques. There are two departments within the Municipality that are directly concerned in the management of municipal solid waste. These departments are the engineering department and the health department. Solid waste is primarily the responsibility of the health department, which is also responsible for its collection, transportation, and disposal." In addition to providing the health department with assistance in terms of both infrastructure and technical matters, the engineering department is responsible for the collection of garbage coming from building and demolition projects. SWM accounts for between 5 and 25 percent of the budgets of the municipal authorities, which translates to between 75 and 250 rupees per person each year. Typically, a city with a population of one million people will spend around ten crores of rupees on this activity.

Quantity and qualities are the two primary aspects that are taken into consideration in the process of designing municipal solid waste management systems that are efficient, cost-effective, and ecologically friendly. In order to determine the amount of solid garbage, the municipal corporation will often rely on the record of the trips taken by the trucks. With that being said, this does not provide an accurate depiction of the development of solid waste. NEERI carried out a study to determine the amount of garbage that is produced in a number of different cities. The amount of solid trash that is generated in urban centres ranges from 0.2 to 0.4 kilogrammes per capita per day, according to studies, while in metropolitan areas, the amount of garbage generated may reach up to 0.5 kilogrammes per capita per day. Refuse has a calorific value that ranges between 800 and 1000 kcal/kg, and its carbon-to-nitrogen ratio ranges between 20 and 30. According to studies on the characterization of municipal solid waste that were carried out by NEERI, thirty to forty percent of the waste contains a significant amount of organic matter, thirty to forty percent of ash and fine earth, three to six percent of paper, and less than one percent of plastic, glass, and metal.

It is common practice in metropolitan areas to engage in the many different kinds of composting. The decade of the 1980s saw the installation of mechanical composting facilities in ten major metropolitan areas; however, at the present time, only one of these plants is operational. A few more plants have been added throughout the course of the years. Due to the very low calorific value of the municipal solid waste in India, the incineration treatment technology has not proven effective in the country. The disposal of solid trash in low-lying regions or open fields is practised without any safeguards being taken and without any operational supervision being present. Pourakarmikas, also known as street sweepers, are responsible for handling solid garbage without taking any appropriate precautions to safeguard themselves from any health risks.

In India, inhabitants often dispose of municipal solid trash by throwing it on the sides of roadways, either in open or enclosed areas along the border of the highways. During a certain time of the day, people of the majority of industrialised countries collect their garbage in polythene bags, seal them, and then deposit them at the designated locations authorised by the government. From that point on, it is the duty of the municipality to collect and compress them, and then transport them to the authorised disposal sites.

In the context of the Indian situation, the existing solid waste is collected from a variety of sources using a collection of diverse ways. The garbage generators are responsible for depositing the trash into the community bins as part of the activity that pertains to the collected solid waste. The garbage is then collected in trucks and put in a few low-lying areas and along the banks of rivers for disposal. The landfills produce an unpleasant odour and pose a threat to public health. These landfills provide a breeding ground for rats, birds, and insects. The rate of decomposition stops short of the dumping spot, which causes the number of dumps to increase in large cities. In this way, fresh locations are transformed into landfills. In order to cut down on the number of dumps, one strategy is to burn the garbage. This results in the production of enormous amounts of sulphurous smoke, which not only contaminate the air in metropolitan areas but also generate thermal pollution and smog. It is the responsibility of junk collectors to choose the remaining pieces that have not been burned and then sell them to junk dealers, who then recycle them. There are a number of nations that do not allow open burning or open dump situations.

The solid wastes are burned in closed incinerators, which are far more efficient and produce significantly less pollution than open incinerators. There are a number of coastal cities that dispose of their rubbish in the ocean, which creates an ecological disturbance for marine life.

At the moment, there is no systematic and scientifically designed arrangement for the separation of solid trash at the community collection bin. In most cases, the solid trash that is produced by a resident is moved into communal bins that are constructed from concrete, metal, or a mix of the two materials. "The community bins are situated in convenient locations, and the members of the community are responsible for transporting the rubbish and disposing of it in the allocated bins. Within the scope of this functional unit, the separation of solid waste, the processing of solid waste, and the transformation of solid waste are all activities that take place largely at sites that are far from the origin of waste production. The separate of bulky goods, the separation of waste components by size using screens, the separation of waste components manually, and the separation of ferrous and non-ferrous metals are all included in the process of segregation". During the processing and transformation of solid waste, the elements of the sorting process were repeatedly mixed up; this occurred on several times as a result of incorrect handling. It is impossible to dispose of solid waste in a scientific manner if sorting is not performed. After the rubbish has been collected, the recyclable items are sorted from the trash. In India, there are certain individuals who simply engage in this sort of employment and make a living by selling renewable materials that they have plucked from rubbish. Following such a waste segregation, the organic matter may be composted, which will result in the formation of manure over the course of time and will result in the trash being turned into a resource that is of great value.

The transportation of solid waste from collection centres to the ultimate disposal site is an additional step that is essential in the management of solid waste. The identification of the suitable vehicles is a crucial undertaking. When choosing cars, it is important to take into consideration a number of criteria, including the volume of transportation, the state of the road, the width of the road, and so on. In order to protect the vehicles from the wear and tear that might be caused by the heat and rain, a suitable garage should be constructed. It is important to do maintenance on the systems in order to extend the lifespan of the vehicles. Additionally, the route that the vehicle takes should be carefully planned in order to maximise the efficiency of the fuel and minimise the amount of time spent travelling. Bullock carts, hand rickshaws, compactors, trucks, tractors, trailers and dumpers are the many forms of transportation that are used in India for the transportation of municipal solid garbage. These vehicles are responsible for transporting the rubbish to main collection centres.

## 4. TREATMENT/ RECYCLING OF SOLID WASTE

In every city, town, and hamlet in India, municipal solid waste is disposed of in a manner that is not scientific. Generally speaking, municipal solid waste is disposed of directly on low-lying regions. The majority of municipal solid waste is disposed of along the roadways on the fringes of the city since almost no "Urban Local Bodies" (ULBs) have suitable engineered landfilling facilities as of yet. During the monsoon season, the most common cause of pollution in water bodies is municipal solid waste (MSW) that has been disposed of in an unscientific manner. Additionally, both ground and surface water bodies get polluted as a result of the percolation of leachate.

There is a widespread acceptance of "the practice of landfilling in India; nevertheless, metropolitan areas such as Bangalore, Delhi, Kolkata, Mumbai, and Chennai are experiencing a shortage of space for the disposal of solid waste, and authorised landfill sites are reaching their maximum. "The expansions of existing sanitary landfill were reported in the states like Karnataka (12 sites), Andhra Pradesh (Vijanagaram), Delhi (Bhalswa, Okhla and Ghazipur), Gujarat, Goa (8 sites), Haryana (Sirs and Ambala), Madhya Pradesh (Gwalior and Indore), Maharashtra (Nashik, Sonpeth, Ambad, Pune, Navapur and Navi Mumbai), Punjab (Adampur), West Bengal (17 sites) and Rajasthan (Jodhpur). According to the CPCB 2013 Report, as of the present moment, India has 376 landfill sites that are now in the design and implementation stage, and 59 landfill sites are currently being created". In addition, 1305 landfill sites have been identified for potential usage in the future.

In order to successfully manage solid waste, one of the steps that must be taken is to choose suitable treatment technologies. This is in addition to taking into consideration other elements such as the recovery of resources, the preservation of the environment, the provision of financial assistance, the participation of stakeholders and the capacity of institutions. Several different methods of treating solid waste are now accessible and are being used all over the globe. During the process of selecting treatment technologies, the primary criteria that are taken into consideration include the amount of trash, the characteristics of waste, the physical qualities and composition of waste, the availability of land, social considerations, capital investment, the length of treatment, the market for goods," and so on. Inappropriate choice of waste technology has the potential to bring about the collapse of the whole waste management system.

In the process of composting, organic waste is transformed into a useful organic fertiliser under regulated conditions. This process is nature's method of recycling a waste product. As a result of the fact that India is mostly an agricultural nation, there is a need for manure among the farmers. Another issue that requires particular attention is the decrease of solid waste via the separation of recyclable items such as cardboard, plastics, glass, and metals, among other things. To further the cause, a non-governmental organisation (also known as an NGOs) could take part in this action. It is important to provide training to rag pickers so that the process of sorting recyclable materials may be carried out in a way that is more scientific and well-organized.

## 5. CHALLENGES IN SOLID WASTE MANAGEMENT

### 5.1 Infrastructure and Resource Constraints

The insufficient infrastructure and the limited availability of resources are two of the most major difficulties that India has when it comes to the management of solid waste. There are a number of cities and towns in India that do not have sufficient garbage collection trucks, waste treatment and disposal facilities, or recycling infrastructure respectively. Inadequate infrastructure creates obstacles for the effective collection, transportation, and treatment of garbage, which ultimately results in insufficient implementation of waste management strategies. The development and maintenance of waste management infrastructure are both significantly hindered by financial restrictions, which play a key influence in the situation. Within the realm of waste management initiatives, limited financial resources can lead to delays or compromises in the execution of those programmes. The term "technical constraints" refers to the limits imposed by technology as well as the need for specialised knowledge and abilities. On the other hand, there is a scarcity of experienced professionals and technical specialists in the area of waste management, which creates obstacles for the adoption and implementation of novel waste management strategies. Challenges pertaining to human resources are another factor that contributes to the limitations in solid waste management. In order to effectively manage garbage, it is necessary to have individuals who have received training. This includes waste collectors, supervisors, engineers, and administrative staff. In many departments that deal with waste management, however, there is a scarcity of workers who have received training. The process of waste management is further complicated by the fact that waste handlers and the general public do not have enough understanding of trash segregation and correct disposal techniques, nor do they get adequate training on these topics. The limitations imposed by India's infrastructure and resources have a direct influence on the efficiency and efficacy of the country's waste management systems.

### 5.2 Institutional and Governance Issues

The successful management of trash necessitates the establishment of distinct functions for different parties involved, along with close cooperation and coordination among public and private organisations. Waste management is an area where several parties' functions are often misaligned and poorly defined. Municipal corporations, local authorities, and private contractors are the usual suspects when it comes to the division of labour for trash collection, transportation, treatment, and disposal. Waste management procedures are inefficient because duties are not clearly defined, leading to overlapping or fragmented efforts. To effectively execute waste management efforts, it is essential for government agencies, municipalities, and commercial companies to work together in coordination. But there are still problems with working together. Inadequate teamwork often results in less-than-ideal waste management techniques and lost chances for progress. Frameworks for policies and

regulations are also part of institutional and governance concerns. Waste management policies and laws in India vary in terms of their efficacy and enforcement between areas and states. An integral part of India's waste management system is the participation of the informal trash sector and ragpickers. Even though they are sometimes unofficial and uncontrolled, ragpickers serve an important role in garbage collection and recycling. There are a number of governance concerns that arise when attempting to incorporate the informal trash sector into official waste management systems. These concerns include problems of acknowledgment, social security, and equitable compensation for their work.

### 5.3 Environmental and Social Impacts

There are major social and environmental consequences to India's poor solid waste management techniques. Sustainable waste management requires an understanding of and response to these implications. Negative consequences for public health might result from inefficient garbage management. The spread of illness and the poisoning of water supplies are both exacerbated by open dumping and insufficient waste treatment facilities. Local populations are in danger of health problems in the long run due to the presence of hazardous garbage in uncontrolled landfills. Additionally, those living in close proximity to trash disposal facilities may have respiratory health issues due to the degradation of air quality caused by the emissions of pollutants from garbage incineration and open burning. Mismanagement of trash has repercussions in social spheres as well as environmental ones. Disenfranchised populations pay a disproportionate price for garbage problems caused by unfair waste management methods. Environmental injustice arises when low-income neighbourhoods are situated near landfills and other trash disposal facilities. Another social issue with waste management systems is the marginalisation and stigmatisation of garbage pickers, who are essential in informal trash management. Furthermore, people's ability to make a living is affected by ineffective waste management techniques, especially for those working in the unofficial recycling industry.

## 6. GUIDELINES AND POLICIES IN MSWM

The Ministry of Environment and Forest and Climate Change (MoEF), the National Environment and Engineering Research Institute (NEERI), the Central Pollution Control Board (CPCB), the Ministry of Urban Development (MoUD), the State Pollution Control Boards (SPCBs), and the Urban Local Bodies (ULBs) are responsible for the administration and regulation of waste management in India. Important measures taken by the Government of India (GOI) regarding solid waste management in India during the last 25 years include the following.

- National waste management committee: The committee was formed in 1990, and its goal is to identify recyclable elements in solid garbage collected by rag-pickers.
- Policy Paper: MoUD and the Central Public Health and Environmental Engineering Organisation (CPHEEO) collaborated to develop a waste water and SWM treatment plan document.
- Strategy Paper: In August 1995, the MoUD collaborated with the NEERI to create a handbook on SWM.
- Master plan of MSW: In March 1995, the MoEF, CPCB, and ULBs collaborated to design a comprehensive biomedical waste management strategy.
- High powered Committee: Using suitable technology, the committee, which was established in 1995, seeks to develop a comprehensive long-term strategy for the SWM.

These laws are relevant to MSW and are enforced by ULBs; they are the Municipal Solid Waste (Management and Handling) laws, 2016. Regulations for the Control, Management, and Handling of Hazardous and Other Wastes (Management and Transboundary Movement) 2016, The regulations that apply to the management and processing of building materials are the building and Demolition Waste Management regulations, 2016. The 2016 Bio-Medical Waste Management Rules address the regulation, administration, and treatment of biomedical waste produced by healthcare facilities and residential care facilities. Stakeholders engaged in the production, handling,

utilisation, processing, and recycling of electronic and electric waste materials are subject to the E-Waste Management and Handling Rules 2016.

The National Green Tribunal has mandated that all states and union territories immediately begin enforcing the Solid Waste Management Rules, 2016; additionally, the judgement calls on state and local governments to issue directives to all parties involved, requiring an improvement in the current methods used to collect, store, transport, dispose of, treat, and recycle the "garbage" that is produced in cities across India. The facility also has the authority to purchase RDF for use as fuel in cement and power plants operating within its jurisdiction, provided that these facilities are not more than 100 km away.

## 7 SUGGESTIONS

### 7.1 Technical Aspects

The following must be considered when the technical aspects of a sustainable SWM are being planned and implemented:

- There must to be sufficient storage facilities and main rubbish collection from communal bins or curbside in densely populated metropolitan areas.
- It is important to improve the trash collection fleet and schedule regular garbage transportation from community storage bins.
- Construction of transfer stations should include provisions for weighbridges wherever they are required.
- Healthcare facilities, businesses, and hospitals are required by law to install their own SWM systems in order to divert hazardous materials and infectious diseases away from municipal waste streams.
- Practices for regularly monitoring trash should be put in place.
- The waste standards must be adhered to.
- Individuals participating in the SWM system may participate in vaccination programmes.

### 7.2 Management Aspects

The establishment of a management sector that collaborates with technical planning is crucial for sustainable SWM. Strong management that takes these things into account can get the job done:

- A national environmental quality strategy and a set of attainable and workable SWM plans at the state or zonal level would be beneficial to management.
- Consistent documentation and tracking of MSW components, together with the establishment of a suitable data system amenable to evaluation, utilisation, and updates
- Encouraging private sector involvement via facilitating a structural support

### 7.3 Financial Aspects

Below are the financial elements that are related to this:

- Administration plans to subsidise local businesses in an effort to boost community involvement and corporate sponsorship
- In order to spend money wisely, it is crucial that all levels of waste management have open communication and work together on operating and maintenance expenses.
- While recycling equipment may be imported tax-free, businesses that rely on garbage and scrap as their primary raw materials are subject to reduced tax advantages.

- Revenue collection process flow management via the application of policy and business drivers or the establishment of financially sustainable practices

### 7.4 Legislative Aspects

Sustainable management of MSWM relies heavily on legislation and the correct application of this legislation. What follows is a list of the relevant details:

- The World Health Organization's (WHO) guidelines, or those of any country's, should be the basis for acceptable pollutant discharge limits for solid waste disposal sources.
- Separation of municipal solid waste management facilities from residential areas and construction zones
- City planning agencies, the Ministry of Finance, and the MoEFCC must work together to create plans for both urban and rural infrastructure.
- Promote new ideas and a robust research and development programme to enhance SWM techniques.
- Legislation should govern landfill designs.

### 7.5 Supportive Aspects

Facilities for transportation, waste management, and disposal must be made available.

- Waste segregation, recycling, and public education initiatives to increase trash segregation
- Workers in the solid waste collection industry may feel safe and included in their communities
- Research, knowledge, and carrying out of official programmes
- Education on the need of trash segregation in homes, communities, and businesses via the adoption of a segregation strategy
- Local governments should get cutting-edge methods.

## CONCLUSIONS

Lacking an adequate solid waste management system in place at the appropriate time, India's municipal solid waste management practices are subpar. The system's implementation and planning by municipal authorities will need to be ahead of schedule to accommodate the ever-increasing metropolitan areas and populations. Professionals with the necessary skills in solid waste management are hard to come by, and MSWM education is lacking. Existing MSWM systems in India are also not held to account. The financial crisis and the rising expenses of implementing collection, segregation, and a government regulatory framework are major challenges to attaining efficient municipal solid waste management in India. Municipal authorities are mostly responsible for this task. In India, solid waste management has not been transformed by innovation or the purchase of current technology due to a lack of environmental consciousness and poor motivation. Public perceptions about solid waste also act as an impediment to the efficient MSWM implementation in India. For the SWM system to continue functioning efficiently, public cooperation is crucial.

Proper waste segregation at the source and subsequent processing via several recycling and resource recovery streams are essential components of effective waste management. Afterwards, sanitary landfills should be used in a scientific manner to dispose the decreased final waste. It is important to take into account the actualities on the ground while establishing MSW regulations, and to provide enough time to build appropriate procedures and systems. Among the most important groups involved in MSWM in India are rag-pickers, whose contributions have, until recently, gone unrecognised. Their proper place in the system must be acknowledged, enhanced, and valued. The rag-pickers are now operating in the unorganised sector; thus, more money and jobs may be created by establishing a well organised sector for recycling dry waste items. Transportation and landfill loads will be reduced as a result of this as well.

**REFERENCES**

1. Sk, M. M.; Ali, S. A.; Ahmad, A., (2020). Optimal sanitary landfill site selection for solid waste disposal in Durgapur city using geographic information system and multi-criteria evaluation technique. KN-Journal of Cartography and Geographic Information, 70, 163-180.
2. Sharma, H. B.; Vanapalli, K. R.; Samal, B.; Cheela, V. S.; Dubey, B. K.; Bhattacharya, J., (2021). Circular economy approach in solid waste management system to achieve UN-SDGs: Solutions for post-COVID recovery. Science of The Total Environment, 800, 149605.
3. Romero-Hernández, O.; Romero, S., (2018). Maximizing the value of waste: From waste management to the circular economy. Thunderbird International Business Review, 60(5), 757-764.
4. Mohan, S.; Joseph, C. P., (2021). Potential hazards due to municipal solid waste open dumping in India. Journal of the Indian Institute of Science, 101(4), 523-536.
5. Mir, I. S.; Cheema, P. P. S.; Singh, S. P., (2021). Implementation analysis of solid waste management in Ludhiana city of Punjab. Environmental Challenges, 2, 100023.
6. Kumar, S., Smith, S.R., Fowler, G., Velis, C., Kumar, S.J., Rena, Arya, S., Kumar, R. and Cheeseman, C. (2017) Challenges and opportunities associated with waste management in India. R. Soc. Open Sci., 4, 1–7.
7. Jha, A.K., Singh, S.K., Singh, G.P. and Gupta, P.K. (2011) Sustainable municipal solid waste management in low income group of cities: A review. Trop. Ecol., 52, 123–131.
8. Schoot Uiterkamp B.J., Azadi, H., Ho, P. (2011) Sustainable recycling model: A comparative analysis between India and Tanzania. Resour. Conserv. Recycl., 55, 344–355.
9. Kumar, S. and Gaikwad, S.A. (2004), "Municipal solid waste management in Indian urban centres: An approach for betterment", in: Gupta K.R. (Ed.), Urban development debates in the new millennium, Atlantic Publishers & Distributors, New Delhi, pp. 100–111.
10. Pappu, A., Saxena, M. and Asolekar, S.R. (2007), "Solid wastes generation in India and their recycling potential in building materials", Building and Environmental, Vol. 42, pp. 2311– 2320.
11. Shekdar, A.V. (2009), "Sustainable solid waste management: An integrated approach for Asian countries", Waste Management, Vol. 29(4), pp. 1438–1448.
12. Idris, A., Inanc, B. and Hassan, M.N. (2004), "Overview of waste disposal and landfills/dumps in Asian countries", Journal of Material Cycles and Waste Management, Vol. 16(2), pp. 104–110.
13. Rajkumar J. and Sirajuddin A. (2016), "Status and challenges of municipal solid waste management in India: A review", Cogent Environmental Science, Vol. 2(1): 1139434, pp. 1-18.
14. Singhal, S. and Pandey, S. (2000), "Solid waste management in India: Status and future directions", TERI Information Monitor on Environmental Sciences, Vol. 6(1), pp. 1–4.
15. Rajkumar, N., Subramani, T. and Elango, L. (2010) Ground water contamination due to municipal solid waste disposal-a GIS based study in Erode City. Int. J. Environ. Sci., 1, 39–55.
16. Singh, S. (2020) Decentralized Solid Waste Management in India: APerspective on Technological Option. National Institute of Urban Affairs, New Delhi. pp. 290–304.