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# Review Study on Solid Waste Management in India an Assessment of Resource Recovery and Environmental Impact

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***Abstract:*** This examination investigations the natural and money related maintainability of strong waste administration in Indian urban areas. It presents an evaluation of the quickly rising volume of metropolitan strong waste, its evolving synthesis, the proceeding with training of blending biodegradable (wet) squander with dry waste at the wellspring of age, and the developing volume of plastic in the waste. The current framework is centered around assortment and transportation of to a great extent blended un-isolated waste. Asset recuperation from the waste and safe removal of the lingering waste in logically planned landfills are horribly disregarded. Rules have now been set up for feasible strong waste administration, yet the ability to design and deal with the framework and guarantee the requirement of the standards is a significant test. The powerlessness to guarantee isolation of waste comes in the method of legitimate reusing, compelling working of bio-methanation plants, and furthermore of safe activity of waste to vitality plants which therefore prompts arrival of harmful poisons into the climate.

Destinations assigned for landfills are utilized as open dumping locales where to an extreme degree an excessive amount of waste is dumped without asset recuperation, creating leachate and methane gas. This examination additionally presents the wellsprings of ozone harming substance outflows from the strong waste segment. Other than introducing some alleviation decisions to react to the developing test, it likewise recommends components for guaranteeing that the framework is monetarily reasonable.

***Keywords:*** Solid Waste Management, Greenhouse Gas Emissions from Solid Waste Sector, Sustainable Materials Management, Waste to Energy.

## I. Introduction

Rising earnings, quickly developing however impromptu urbanization, and changing ways of life have brought about expanded volumes and evolving organization (expanding utilization of paper, plastic and other inorganic materials) of civil strong waste in India. The volume of waste is anticipated to increment from 64-72 million tons at present to 125 million tons by 2031. Untreated waste (a blend of biodegradable or wet waste and non-biodegradable waste) from Indian urban areas lies for a considerable length of time and years at dumpsites where land was initially apportioned for creating landfills for safe removal of just the leftover waste.

The deterioration of natural issue in the airless piles of waste at these dumpsites adds to a dangerous atmospheric deviation by Green House Gas outflows. Since the current age of waste is likewise not dealt with successfully, it fuels the issue. In a perfect world, the foundation and conveyance systems for strong waste administration, seepage, sewerage, and waste water treatment ought to be arranged and actualized in a co-ordinated structure of a city improvement plan. Other than focusing on improve the quick ecological and general wellbeing emergencies coming about because of the current poor condition of strong waste administration, there is requirement for a plainly enunciated medium term technique to address the difficulties of strong waste administration in Indian urban areas.

- Strong Waste Management Rules (2016) give a sensible system to address the numerous difficulties of city strong waste administration in India.
- They are a huge improvement over the Municipal Solid Waste Management Rules (2000), which was the first run through such standards were ever informed for Indian urban communities.
- 3 Strategic course and financing by the Government of India through national missions, for example, JNNURM, AMRUT, Smart Cities and Swachh Bharat Mission have likewise made a situation in which there is all the more however in no way, shape or form sufficient spotlight on the issue. It is critical to interpret the vision from the Rules and the Missions into an operational coordinated methodology of strong waste administration

### . Municipal Solid Waste Scenario in India

Civil strong waste is characterized to incorporate family waste, business and market territory squander, butcher house squander, institutional waste (e.g., from schools, network corridors), plant squander (from parks and gardens), squander from street clearing, residue from seepage, and treated biomedical waste. Development and Demolition (C&D) squander used to be characterized as a component of metropolitan strong waste up to this point, however Solid Waste Management Rules 2016 have removed C&D squander from the definition and C&D Waste Management Rules 2016 have been independently notified.4 Until legitimate frameworks are set up for overseeing C&D squander in consistence with the new Rules, there is peril of disregarding C&D squander in the progress, while the volume of C&D squander is probably going to develop quickly with the expansion in development movement as India returns to the direction of fast development.

There are no dependable assessments of civil strong waste age in India. The option accessible evaluations are introduced in Table 1. The most recent accessible authority appraisals of MSW age from the Central Pollution Control Board and the Ministry of Urban Development, Government of India are for 2014-15 and they place yearly age of MSW at 52 million tons. The Report of the Task Force on Waste to Energy of the Planning Commission in 2014 assessments MSW age at 62 million tons in 2013-14. Accepting urban populace of 440 million out of 2017(in light of projections from United Nations populace gauges) and per capita day by day squander age of 450 gm, the MSW produced for 2017 comes to 72 million tons. On the off chance that the suspicion as for per capita day by day squander age is brought down to 400 gm, the gauge of MSW produced for 2017 is lower, i.e., 64 million tons. This does exclude electronic waste which is evaluated at near 2 million tons in 2017 and a significant obscure, i.e., Construction and Demolition squander for which the appraisals run from a minor 10 million tons for each annum to a massively bigger volume of 520million tons for every annum, with some recommending that C&D squander is around 30 percent of the absolute waste.

A couple of little urban areas have gained significant ground on entryway to entryway assortment and isolation on account of a persuasive situation gave by the Swachh Bharat Mission. Suryapet in Telangana, Gangtok in Sikkim, and Bobbili in Andhra Pradesh are completing 100 percent entryway to entryway assortment. Tirunelveli in Tamil Nadu, Vengurla in Maharashtra, and UttarparaKotrung in West Bengal have not just achieved 100 percent entryway to- entryway assortment yet in addition 100 percent isolation. In Bobbili, the city laborers isolate the waste. These towns have gone above and beyond by fertilizing the soil all their wet waste. In Alappuzha in Kerala, the Municipal Corporation doesn't gather wet waste; it is prepared by occupants at their home through fertilizing the soil or bio-gas (CSE 2016).

### I. Resource Recovery

Asset recuperation includes use or extraction of disposed of materials from squander for reuse in order to concede utilization of virgin assets, relieve nursery impact, and limit the measure of waste arranged into landfills. Reusing, fertilizing the soil, and vitality age from squander offer elective prospects of asset recuperation with the goal that waste going into landfills is limited. A significant instrument of asset recuperation is supportable material administration which includes utilizing and reusing materials all the more profitably over their whole life cycle. It calls for accentuation on devouring less and lessening natural effect of utilization by utilizing and reusing materials underway. While it requires crucial change in the conduct and example of utilization and creation (counting bundling), maintainable material administration brings about expansion of assets for later use consequently. A point by point evaluation of an item's life cycle from extraction to end-of-life helps in better understanding its effect on the earth, along these lines empowering progressively educated choices for making new roads to lessen expenses and save assets. Broadened Producer Responsibility (EPR) and Take-back plans are instances of concentrating on the finish of- utilization treatment of purchaser items and their bundling, and advancing asset recuperation by the makers themselves.

### V. Recycling of Non-Biodegradable Waste

Asset recuperation includes use or extraction of disposed of materials from squander for reuse in order to concede utilization of virgin assets, relieve nursery impact, and limit the measure of waste arranged into landfills. Reusing, fertilizing the soil, and vitality age from squander offer elective prospects of asset recuperation with the goal that waste going into landfills is limited. A significant instrument of asset recuperation is supportable material administration which includes utilizing and reusing materials all the more profitably over their whole life cycle. It calls for accentuation on devouring less and lessening natural effect of utilization by utilizing and reusing materials underway. While it requires crucial change in the conduct and example of utilization and creation (counting bundling), maintainable material administration brings about expansion of assets for later use consequently. A point by point evaluation of an item's life cycle from extraction to end-of-life helps in better understanding its effect on the earth, along these lines empowering progressively educated choices for making new roads to lessen and save assets. Extended Producer Responsibility (EPR) and Take-back plans are instances of concentrating on the finish of- utilization treatment of purchaser items and their bundling, and advancing asset recuperation by the makers themselves.

The Central Pollution Control Board estimated in 2013 that about 8 to 9 per cent of the total municipal solid waste in India is plastic waste, of which about 60 per cent is recycled, most of it in the informal sector. A study by National Chemical Laboratory, Pune (2017) estimates that PET recycling in India at 90 per cent is much higher than 72 per cent in Japan, 48 per cent in Europe and 31 per cent in the US. While the recycling rate of plastic in India is considerably higher than the global average of around 15 per cent, there still remains a significant amount of plastic waste rendered unrecyclable mostly due to mixing of different streams of waste, which is either land filled or ends up clogging drains/sewers or polluting groundwater resources.

The recycling rate of paper and paper-based products in India is 27 per cent, much lower than in industrialized countries such as Germany (73 per cent), Sweden (69 per cent), Japan (60 per cent) and USA (49 per cent) (CPPRI 2013), where it is mostly exported to recyclers. 11 According to industry assessments, more than 50 per cent of the business requirements of paper in India are met by imported waste-paper, a third of which is from the US. Recycling of waste paper also results in savings of up to 70 per cent of resources such as energy and water compared to making paper from wood pulp. Even more so than in the case of plastic, lack of segregation and no separate primary collection system for recyclables plays a spoilsport because paper is easily soiled. Proper handling and management of waste paper would save not only foreign exchange but also precious resources such as water and trees, and avoid greenhouse gases that would be emitted in the process of production from virgin material. Thus, for every 1 per cent increase in waste paper recovery, approximately 20 kilo tonne of greenhouse gas emissions could be avoided directly on an annual basis, according to a study by the Central Pulp and Paper Research Institute (2013).

It is clear that the method of recovering resources from solid waste depends on the contents of the waste which is not easily discernible particularly when different types of waste are mixed. For example, biodegradable waste can be processed into compost or can be used to generate biogas, while high-calorie, non-recyclable dry waste can be shredded into refuse derived fuel (RDF) for replacing coal in high temperature furnaces (e.g., cement kilns and boilers) or in waste to energy plants.

**Biodegradable Waste Processing**

Biodegradable waste is typically of plant or animal origin and can be decomposed by living organisms. Biodegradable waste in the form of food waste from kitchens of households and restaurants, abattoir waste, and horticulture waste forms a major part of municipal solid waste. When the organic matter in the waste decomposes in the presence of oxygen (aerobic decomposition), it breaks down into simpler compounds with the release of carbon dioxide and water, and produces compost which is useful for nourishment of the soil. Alternatively, anaerobic decomposition in the absence of oxygen converts the organic material in the biodegradable waste into methane and liquid slurry, which are useful as bio-fuel and manure, respectively.

- **Composting :**

Deterioration of natural issue in the loss within the sight of oxygen with the assistance of miniaturized scale life forms or worms, (for example, red wigglers or night crawlers) produces manure or Vermin compost, which is a humus rich soil conditioner. City fertilizer from the biodegradable civil strong waste gives an option in contrast to yard excrement (like dairy animals compost) which has been esteemed from days of yore for its rich microbial substance that causes plants to take up soil supplements. It not just reestablishes natural issue in the dirt yet in addition gives explicit supplements and diminishes the necessity of compound composts. Use of fertilizer improves water maintenance limit of the dirt and assists with dry spell sealing. The necessity of less water per crop is an invite include for a water-focused on future. By making soil permeable, fertilizer additionally makes attaches more grounded and impervious to bugs and rot. India's farming soil is seriously carbon insufficient because of development of a similar yield year over year, and unreasonable utilization of urea. Utilization of manure renews the natural carbon substance of the dirt.

- **Bio- methanation**

A technically more advanced method for bio-chemical conversion of biodegradable waste is anaerobic decomposition or bio-methanation. With the action of microbes in the absence of oxygen, the organic matter is broken down with the release of biogas which contains methane. The gas can be used in place of conventional fuels like LPG or CNG. It can also be concentrated and bottled into Compressed Biogas (CBG) which in turn can be converted into electricity with the use of generators yielding 30 per cent electricity conversion efficiency. However, almost 70 per cent of the energy is lost as heat in the process of conversion. A byproduct of bio-methanation is slurry which is an excellent liquid manure for agriculture. Bio- methanation therefore not only produces energy but also delivers nutrients for soil.

## VI. Greenhouse Gas Emissions from Solid Waste Sector

Ozone harming substances (GHGs) have been a wellspring of developing worry because of changing atmosphere examples and outrageous climate occasions all through the planet. GHGs make a characteristic cover around the Earth's environment by forestalling a portion of the sun's warmth vitality from emanating again into space, subsequently keeping the earth warm. Be that as it may, in the course of the only remaining century and a half, human exercises have added significantly to GHGs in the air, and that keeps on bringing about an unnatural weather change, making the world's normal temperature rise and in this way prompting change in climatic examples. Strong waste area is a huge benefactor of GHG outflows all around. The Inter Governmental Panel on Climate Change (IPCC) assessed that post- buyer squander represented up to 5 percent of the absolute worldwide GHG outflows in 2005 (IPCC 2007). Ozone harming substances are produced not just while the waste is overseen (as during transportation) yet additionally when it is left to rot in dumpsites. A lot of typified outflows is related with poor waste administration, which can be stayed away from with legitimate taking care of, asset recuperation and reusing. Squander minimization at source in all divisions of an economy has impressive downstream GHG decrease potential.

## VII. Towards Sustainable Solid Waste Management

The two overwhelming challenges facing urban local governments in putting an effective solid waste management system in place are

- Environmental sustainability

- Financial sustainability.

Chart 1: Definition of Municipal Solid Waste

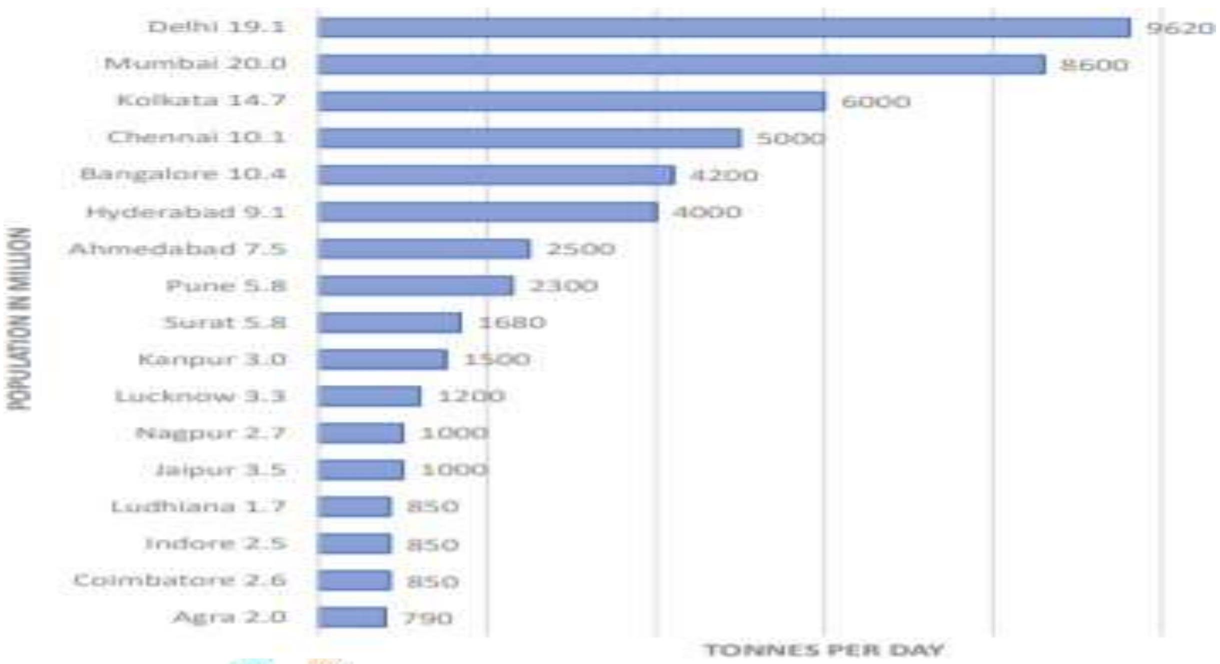

Note: Construction and Demolition (C&D) waste is no longer a part of municipal solid waste. C&D Waste Management Rules 2016, Plastic Waste Management Rules 2016, E-Waste ManagementRules 2016, Biomedical Waste Management Rules 2016, and Hazardous and Other Waste Management Rules 2016 are separately notified by MoEF & CC.

**Table 1: Alternative Estimates for Municipal Solid Waste Generation**

| **Year** | **Source** | **Annual Generation** (million tonnes) |
|---|---|---|
| 2017 | **Our estimate 1** based on 450 gm per capita daily generation and urban population of 440 million* | 72 |
| 2017 | **Our estimate 2** based on 400 gm per capita daily generation and urban population of 440 million* | 64 |
| 2014- 15 | **Central Pollution Control Board** | 52 |
| 2014- 15 | **Ministry of Urban Development** | 52 |
| 2013- 14 | **Task Force on Waste to Energy, Planning Commission** | 62 |

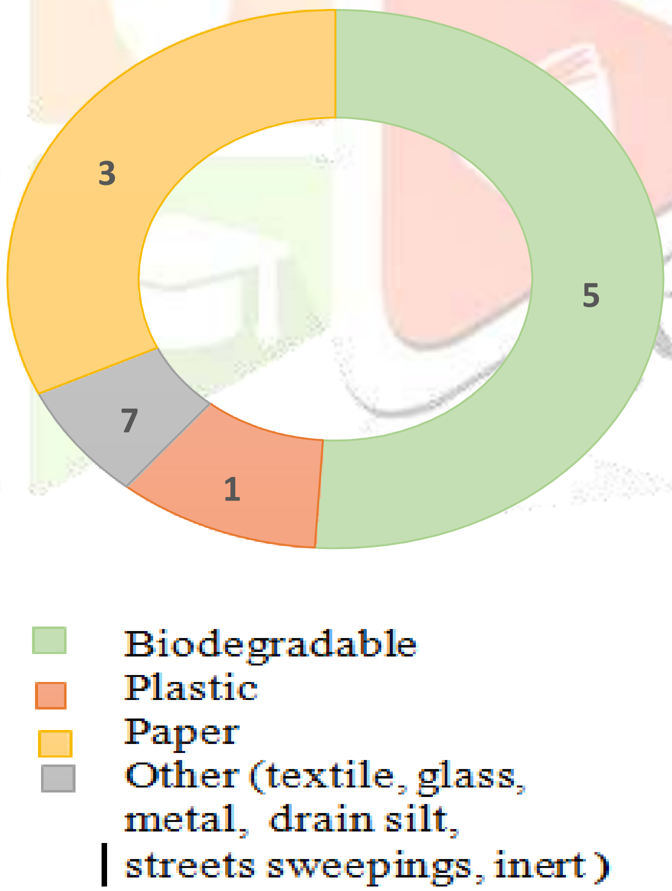
*Based on projections from United Nations Estimates.
Source: Central Pollution Control Board, Ministry of Urban Development, and Planning Commission

**Chart 2: Top MSW Generating Cities/ UAs in India 2016**




Source: State Pollution Control Boards, Municipal Corporations, and UN population estimates

**Chart 3: Composition of Municipal Solid Waste in India (per cent of total)**



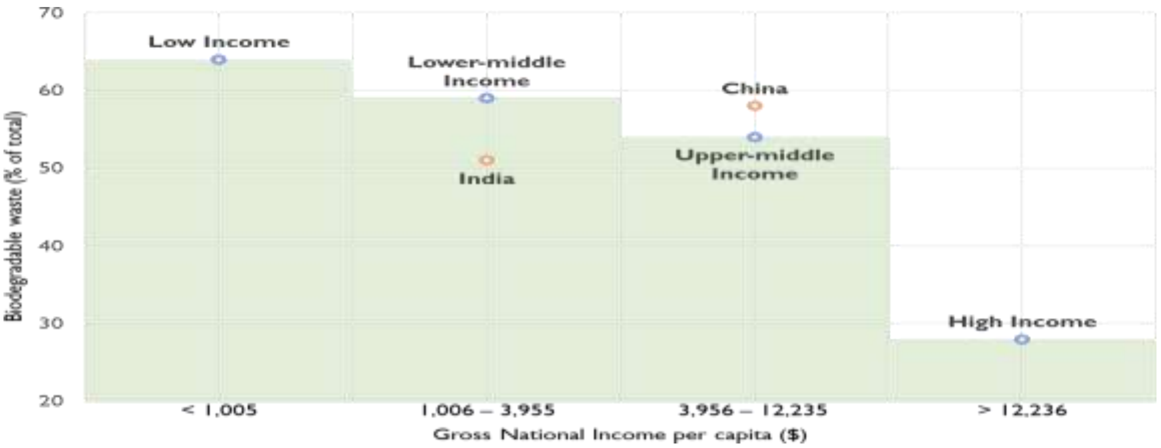



**Chart 4: Biodegradable Waste Generation: India, China and Other Countries**

**Note:** Groups Classified according to The World Bank estimates of 2018 GNI per capita
Source: What a Waste, The World Bank, 2012.

**Table 2: Estimates of Collection and Segregation at Source: Municipal Solid Waste Selected Cities**

| City | State | Populatio n (million) | Door-to-door Collection from Households (%) | n at Source (%) |
|---|---|---|---|---|
| | | | | Large Citie |
| Mumbai | Maharashtra | 20.( | 80 | - |
| Delhi | - | 19.1 | 39 | - |
| Bengaluru | Karnataka | 10.4 | 71 | 5( |
| Chennai | Tamil Nadu | 10.( | 80 | - |
| Hyderabad | Telangana | 9.1 | 73 | - |
| daba d | Gujarat | 7.5 | 95 | - |
| Surat | Gujarat | 5.8 | 60 | 12 |
| Pune | Maharashtra | 5.8 | 50 | 52 |
| | | | | Mid-size Citie |
| Indore | Madhya Pradesh | 2.5 | 90 | 53 |
| Bhopal | Madhya Pradesh | 2.1 | 100 | na |
| Ludhiana | Punjab | 1.7 | 25 | - |
| Chandigarh | - | 1.2 | 95 | - |
| Mysuru | Karnataka | 1.( | 95 | 55 |
| | | | | Small Citie |
| Warangal | Telangana | 0.9 | 90 | na |
| Tirunelvel | Tamil Nadu | 0.5 | 100 | 10( |
| Alappuzha | Kerala | 0.2 | 100 | 76 |
| Suryapet | Telangana | 0.1 | 100 | na |
| Gangtok | Sikkim | 0.1 | 90 | 30 |
| Panaji | Goa | 0.07 | 100 | 9( |

**Note:** Large cities imply population greater than 5 million, mid-sized 1 million to 5 million and small cities less than 1 million. Data for Kolkata are unavailable. Source: Municipal Bodies of different societies miscellaneous.

**Table 3: Installed and Operational Capacity of Compost Plants in India by State**

| State | Number of Plants | lled Capacity (tonnes/year | Operational Capacity (%) |
|---|---|---|---|
| A&N Islands | 1 | 90 | - |
| Andhra Pradesh | 2 | 2,400 | 20.0 |
| Assam | 1 | 15,000 | 15.0 |
| Chhattisgarh | 1 | 1,200 | 20.0 |
| Daman & Diu | 1 | 4,050 | - |
| Delhi | 4 | 1,68,000 | 16.1 |
| Goa | 1 | 1,200 | 20.0 |
| Gujarat | 15 | 1,74,300 | 19.5 |
| Haryana | 4 | 18,600 | 15.3 |
| Karnataka | 18 | 4,73,400 | 10.1 |
| Kerala | 3 | 1,56,000 | 20.0 |
| Madhya Pradesh | 1 | 36,000 | 15.0 |
| Maharashtra | 13 | 4,88,400 | 12.5 |
| Punjab | 2 | 19,200 | 15.0 |
| Rajasthan | 1 | 1,80,000 | 15.0 |
| Tamil Nadu | 9 | 67,680 | 15.8 |
| Telangana | 5 | 1,92,000 | 15.0 |
| Tripura | 1 | 75,000 | 6.0 |
| Uttar Pradesh | 7 | 1,24,560 | 15.2 |
| West Bengal | 5 | 1,70,400 | 15.0 |
| **Total** | **95** | **23,67,480** | 14.0 |

Source: 34th Report on Implementation of Policy on Promotion of City Compost, Standing Committee on Chemicals and Fertilisers of the 16th Lok Sabha (2017)

**Table 4: Medium and Large-scale Bio- methanation Plants in India**

| City | Developer | Installed Capacity (TPD) | Output |
|---|---|---|---|
| Pune | Nobel Exchange | 300* | Bio-CNG: 4 TPD<br>Manure: 7.5 TPD |
| Bengaluru | Nobel Exchange | 250# | Bio-CNG: - TPD<br>Manure: 25 TPD |
| Solapur | Organic Recyclers | 400# | Electricity: 3 MW<br>Manure: 60 TPD |
| Chennai | Ramky | 30 | Electricity: 0.26 MW<br>Manure: 3 TPD |

* Operational capacity as of 2017 is 25%
# Currently operational capacity not available
Source: Municipal Bodies of different cities/ miscellaneous

**Table 5: RDF Plants in Operation in India**

| Location | Developer | Capacity (TPD) | RDF (TPD) |
|---|---|---|---|
| Kochi | Kochi MC | 400 | 100 |
| Jaipur | Vikram Cements | 500 | 150 |
| Surat | Hanjer | 500 | 125 |
| Chandigarh | Jaypee | 500 | 300 |
| Pune | Rochem | 400 | 250 |
| Navi Mumbai | Pyrocrat | 300 | - |
| Bengaluru | MSGP | 500 | - |
| Bengaluru | KCDC | 200 | - |

Source: Municipal Bodies of different cities/ miscellaneous

**Table 6: Waste-to-Energy Plants in Operation in India**

| Location | Developer | apacity (TPD) | y Generation (MW) |
|---|---|---|---|
| Delhi – Okhla | Jindal | 1,95( | 16.( |
| Delhi – Ghazipur | IL&FS | 1,30( | 14.( |
| Delhi – Bawana | Ramky | 2,00( | 24.( |
| Hyderabad | Ramky | 2,40( | 20.( |
| Hyderabad | IL&FS | 1,00( | 11.( |
| Chennai | Essel | 30( | 2.9 |
| Jabalpur (MP) | Essel | 60( | 9 |
| Shimla | Elephant Energy | 7( | 1.75 |

Source: Municipal Bodies of different cities/ miscellaneous

**Table 7: Estimated City-wise CO2e Emissions from Landfill Sites in 2016**

| | Total MSW (tonne/day) | MSW dumped | O2e emission (tonne/day) | CO2e emission (kilotonne/yr) | Equivalence to passenger vehicles (thousands, /yr)* |
|---|---|---|---|---|---|
| **Delhi** | 9,62( | 50% | 1,764 | 643.7 | 137 |
| **Mumbai** | 8,60( | 80% | 2,523 | 920.8 | 196 |
| **Chennai** | 5,00( | 80% | 1,467 | 535.3 | 114 |
| **Bengaluru** | 4,20( | 60% | 924 | 337.3 | 72 |
| **Pune** | 1,60( | 35% | 205 | 74.9 | 16 |
| **Indore** | 70( | 60% | 154 | 56.2 | 12 |
| **Chandigarh** | 45( | 60% | 99 | 36.1 | 8 |

***** Assuming mileage of 9.2 kilo-metre per litre and 18,350 kilo-metre driven in a year, a typical passenger vehicle would emit 1 kilo-tonne of CO2e GHG after driving 3,900 thousand kilo-metre, i.e. 10 times the distance to moon!

**Table 8: GHG and Energy savings from materials recycled in USA**

| | )2e saved per tonne of material recycled | ıergy requirement as a per cent of virgin production |
|---|---|---|
| **Paper** | 838 - 937 | 50 |
| **Aluminium** | 407ç | 10 |
| **Steel** | 54( | 50 |
| **Glass** | 8ε | - |
| **Plastic** | 0 - 507 | - |

Source: US Environment Protection Agency, 2006

**Table 9: Land Allocated for Developing Landfills**

| City | Number of known landfills sites | Area (acre) |
|---|---|---|
| Chennai | 2 | 1150.3 |
| Coimbatore | 2 | 721.5 |
| Surat | 1 | 494.2 |
| Mumbai | 3 | 345.9 |
| Hyderabad | 1 | 300.2 |
| Ahmedabad | 1 | 207.6 |
| Delhi | 3 | 164.1 |
| Jabalpur | 1 | 150.7 |
| Indore | 1 | 147.0 |
| Madurai | 1 | 120.1 |
| Bengaluru | 2 | 100.6 |
| Vishakhapatnam | 1 | 100.1 |
| Ludhiana | 1 | 99.8 |
| Nasik | 1 | 85.0 |
| Jaipur | 3 | 77.6 |
| Srinagar | 1 | 75.1 |
| Kanpur | 1 | 61.0 |
| Kolkata | 1 | 61.0 |
| Chandigarh | 1 | 44.5 |
| Ranchi | 1 | 37.1 |
| Raipur | 1 | 36.1 |
| Meerut | 2 | 35.1 |
| Guwahati | 1 | 32.6 |
| Thiruvananthapuram | 1 | 30.0 |
| Vadodara | 1 | 20.0 |
| Dehradun | 1 | 11.1 |
| Jamshedpur | 2 | 10.1 |
| Faridabad | 3 | 5.9 |
| Asansol | 1 | 4.9 |
| Varanasi | 1 | 4.9 |
| Agra | 1 | 3.7 |
| Lucknow | 1 | 3.5 |
| Rajkot | 2 | 3.0 |
| Shimla | 1 | 1.5 |

Source: Central Pollution Control Board, 2011.

**Conclusion :**

In our study we found that in the inability to ensure segregation of waste comes in the way of proper recycling, effective functioning of biomethanation plants, and also of safe operation of waste to energy plants which consequently leads to release of toxic pollutants into the atmosphere. Sites allocated for landfills are used as open dumping sites where far too much waste is dumped without resource recovery, generating leachate and methane gas.

This study also presents the sources of greenhouse gas emissions from the solid waste sector. Besides presenting some mitigation choices to respond to the growing challenge, it also suggests mechanisms for ensuring that the system is financially sustainable.

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