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Analysis of Solid Waste Management Scenarios in India: A Comparative Case Study of Indore and Varanasi with Special Emphasis on Policy Gaps and Interventions

Deepak Rathore,[†] Ravikant Dubey[†] Ram Sharan Singh[¥] and Amrita Dwivedi[†*]

Abstract

Varanasi, the spiritual capital of India, is prominent in the country. It drastically improved its waste management capacity after 2014, when it became the constituency of the prime minister of India. At the same time, Indore established itself as a role model for sanitation in general and solid waste management in particular by securing the title of the cleanest city in India for the fifth consecutive year.

Solid waste management is the biggest challenge in India, and it is growing continuously. A comparison between Indore and Varanasi will reveal the gaps in solid waste management in India's two-tier towns. Comparative data analysis of the solid waste composition, chemical composition, cleaning, collection, transportation, treatment, and disposal facilities will provide insight into the shortcomings of waste management. Analysing waste generation in different states and cities with varying population densities will reveal the patterns responsible for better or worse waste management in specific areas. We have analysed data and recognised patterns of waste generation with regard to economic prosperity. This study analyses the policy framework for waste and sanitation in India in comparison to the global context. Many successful policy frameworks are designed by international organisations like the United Nations Environment Programme (UNEP), the United Nations Economic Commission for Europe (UNECE) and the World Bank. We have compared the Indian waste management policy and status with the World Bank's policy framework, as it is the most comprehensive policy framework currently available. We have primarily focused on Indore and compared it with Varanasi regarding policy frameworks and enforcement strategies. This study identifies potential gaps by analysing patterns in waste management and proposes improved ideas for waste-related policies and sustainable development.

Keywords: Solid Waste; Waste Composition; Waste Collection; Treatment and Disposal; Sustainable Development; Indore; Varanasi; India

[†] Department of Humanistic Studies, Indian Institute of Technology, Banaras Hindu University, Varanasi 221005, Uttar Pradesh, India
[¥] Department of Chemical Engineering, Indian Institute of Technology, Banaras Hindu University, Varanasi 221005 Uttar Pradesh, India
[*]Corresponding Author Email: amrita.hss@itbhu.ac.in
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Introduction

It is reckoned that India, achieving the highest growth rate in terms of GDP this year compared to other countries, will embrace consumerism fully. This economic growth will bring many positive attributes to the lives of Indian citizens. But the negative side will also haunt India if we do not appropriately address solid waste management challenges (Kumar et al., 2017). Solid waste is increasing by leaps and bounds day by day. In 2015, the generation of waste in the world stood at 2 billion tonnes. Solid waste generation across the globe is poised to increase by up to 3.5 billion tonnes by 2050. This large amount of solid waste will significantly threaten the living world. According to a study, 8,000,000 tonnes of plastic litter reaches the ocean globally (Kaza et al., 2018). Many efforts are being made by different organisations worldwide to overcome this menace of solid waste generation. The United Nations put in the greatest combined effort. The United Nations has set some sustainable development goals SDGs for protecting the environment by describing sustainable ways of production and consumption. Waste management is important in these SDGs. SDG 11.6.1 expressly underlines the waste treated by the controlled facilities out of the total waste collected. UN-Habitat is a wing of the United Nations and is entrusted to take care of SDG 11.6.1. There is mention of other SDGs about solid waste management, like food waste (target 12.3), chemical and hazardous waste management with special mention of e-waste (target 12.4), municipal solid waste (target 11.6), and recycling (target 12.5). Some other factors have indirect mention, like eliminating dumping to improve water quality (target 1.4) and marine litter (target 4.1) (Clark & Wu, 2016).

India, with a population of 1.2 billion,[1] is the largest country in the world; by this, we can quickly elucidate that if India manages to comply with the solid waste management regime, 1/5 of the world is following the solid waste management regime. In India, solid waste management emerged as a critical challenge for policymakers. India has achieved new heights in overall development, including social and environmental areas, but solid waste management needs to be added to the priority list (Mani & Singh, 2016). However, there were rules and regulations for SWM (Solid Waste Management Rules 2000), and it was amended in 2016 (Solid Waste Management and handling Rules 2016) that this area got its due attention. Before it, solid waste was a big nuisance (still, it continues to be a big challenge). A big push by the Government of India in the overall sanitation area has boosted solid waste management. India produced 1,60,038.9 TDP(tonnes per day) of waste, according to the 2021 solid waste management report. The collection was a problem earlier, but in recent years this area has shown notable improvements. Today the collection efficiency stands at 95% of the total waste collected; almost 50% can be treated, while 18% goes to landfills. Although the government puts in so much effort, around 31% of the waste collected still needs to be accounted for. Out of 29 States and Union Territories (UT), 16 States and UT are processing more than 50% of their waste. States like Bihar could be performing better in SWM processing. Among all the states and Union Territories, three states /UT are performing very well. Chandigarh, Chhattisgarh and Sikkim are processing almost all the waste produced within their areas. If we look state-wise, Maharashtra is producing more waste as compared to the other Indian states. Maharashtra, with 22,632 TDP, is ranked first in waste generation. Sikkim produces minimum waste when we consider only states. With just 71 TDP of waste, Sikkim is last on the table. If we also consider Union Territories, then Lakshadweep produces the least waste, 35 TDP (CPCB, 2021, Annual report on solid waste management). City-wise, Mumbai is producing a maximum waste of 11,000 TDP. Among the 46 metro cities under observation for solid waste management, Ranchi has the least waste, 150 TDP. Waste produced by the 46 cities under the

[1] According to the Census of India, 2011

study of CPCB was around 62,000 TDP. The top 5 produce 50% of the waste of all these cities combined, Mumbai, Delhi, Chennai, Hyderabad and Kolkata. This establishes that if we can manage the waste of big metropolitan cities, it will be easier to handle the waste nationally. The same is the case with all the states; around 45% of the total waste generated by the country is produced by the top 5 states: Maharashtra, Uttar Pradesh, West Bengal, Karnataka and Gujarat, respectively (CPCB,2015, Trends of solid waste generation in 46 cities).

Japan and the European Union were the first to propose the comprehensive concept of solid waste management. To achieve the affordability of solid waste management systems, Japan and the European Union are now focusing more on a circular economy. The European Union earlier set a target of 50% recycling of municipal waste by 2020. Now, they have set a new goal for 2030: to recycle 65% of municipal waste and reduce landfills to 10% of municipal waste.

This paper has analysed the current waste management scenarios for Varanasi and Indore, including the physical and chemical composition of waste. Then, we analysed both cities' cleaning, collection, transportation, transfer, and treatment systems. We analyse the relation between waste generation and GDP growth. A policy roadmap for waste generation is discussed in the wake of World Bank documents. Policy gaps and interventions are thoroughly assessed, and recommendations are provided for enhancing the functioning of the waste management system in Varanasi city.

Current Scenario of Solid Waste Management in Varanasi

City Profiles

Varanasi is situated in the eastern part of Uttar Pradesh, on the banks of the River Ganga. The location of this city is between 25.3176°N and 82.9739°E. It is a famous pilgrimage city, often referred to as the spiritual capital of India, dedicated to Lord Shiva. The Varanasi district covers an area of approximately 163.8 square kilometres, while the city area of Varanasi is around 82.5 square kilometres. This area is under the jurisdiction of Varanasi Municipal Corporation. The population of Varanasi city, according to the 2011 census, is approximately 11,98,491 (Census of India, 2011). According to the decadal growth rate of Varanasi, which was 17.15% from 2001 to 2011, the population of Varanasi city will be around 14,04,032. With a population density of about 17122 per square kilometre, Varanasi city is harbouring one of the highest population densities in India.[2]

Indore is located in the state of Madhya Pradesh. It is in the Western part of Madhya Pradesh. It is geographically part of the Malwa plateau. This city is located at 22.7196°N and 75.8577°E. This city is situated between two rivers, the River Saraswati and the River Khan. The area of Indore Municipal Corporation is 275 square kilometres. Indore has a population of around 21,95,974 (Census of India, 2011). If we go by the simple logic of decadal growth, then Indore will have a population of 29,18,449. The population density of Indore is 10612.

Solid Waste Generation in Varanasi City

Varanasi generates approximately 600 tons of waste per day. There are 90 wards in Varanasi, and every ward has its own dynamics of waste generation and collection. Twelve wards generate 0-2 TDP of waste, and 11 wards generate 13-14 TDP. To better visualise the waste generation pattern of Varanasi, we analyse it at the ward level (Figure 1) (Manuja & Singh et al., 2020).

Solid Waste Composition

Solid waste composition is a crucial parameter when managing solid waste. It provides valuable data on the quantity of a specific material in the trash, offering better insight into the planning of recycling, reuse, or disposal of that material.

Some standard components of solid waste include:

Plastic is a significant component in today's waste. It contains water bottles, packaging

[2] Circular economy is a system that emphasises reuse and recycling to create a closed-loop consumption cycle.

material made of plastic, pipes, carry bags, containers, and many more. Most things are replaced by plastic, which was earlier made from metal. Plastic constitutes almost 5-15 % of the waste in cities, as Table 1 demonstrates.

Paper and cardboard constitute a significant fraction of waste. This includes office paper, newspaper, packaging paper, cardboard boxes, and other paper products.

Glass: Glass is an essential material for the manufacturing of many items. Bottles, laboratory glassware, bulbs and tube lights, glass containers, and jars for household purposes constitute a significant portion of solid waste.

Metal: Metal is widely used in the packaging of grocery items. Aluminium cans make up a significant portion of metal waste.

Organic waste: Organic waste comes from any living source, such as animals, plants, fungi, and microorganisms. It is biodegradable and thus used for composting. It includes leftover food, yard trimmings, wood items (furniture, etc.), and agriculture waste.

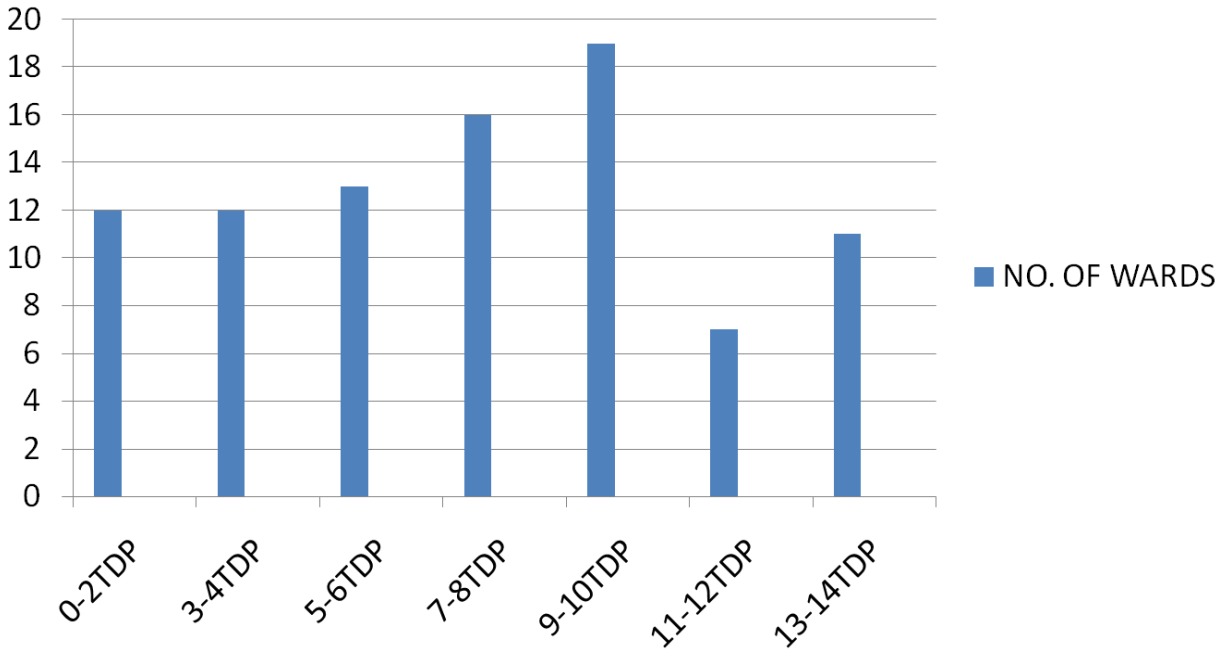

Figure 1: Ward-wise Generation of Solid Waste in Varanasi City
Sources: Varanasi Municipal Corporation, 2019, Solid Waste Management Plan

The composition of solid waste can vary significantly depending on the specific source of the waste and the local regulations and waste management practices in place.

Varanasi has more organic waste than Indore, but if we add paper waste, both cities will have almost equal organic waste. So, the question is, who manages its organic waste better? In this area, Indore seems to be a clear winner. In the case of plastic waste, Varanasi produces almost double the plastic waste compared to Indore; this may be because of Indore's strict plastic ban policy. More than strict policy, enforcement of policy is better in Indore than in Varanasi (IMC CSE, 2016, Swachh Bharat Mission). The next significant category is other, called inert in scientific language. Inert matter usually goes for dumping. Indore is producing more waste in other or mixed categories. So dumping is an important part as long as we start to use all our waste. Dumping is important as it poses a significant environmental threat if not done correctly (Dasgupta et al., 2013). As it is clear from Table 1, almost all the leading cities worldwide have about 50% of organic waste. Depending upon the location of the cities, whether they are located in the developed world or developing, the percentage of organic waste is more or less than 50%. Most developed cities have less organic waste than developing nations.

Table 1: Waste Composition of Different Cities with Reference to Varanasi and Indore

S. No	City	Organic Waste	Paper	Plastic	Textile	Glass	Metal	Others
1	Varanasi	45 %	3 %	10 %	5.2 %	6 %	1.1 %	29.3 %
2	Indore	40 %	8.2 %	5.8 %	5 %	5 %	0.89 %	35 %
3	Mysuru	41.5 %	-	10 %	1.5 %	8 %	2 %	37 %
4	Surat	39 %	8.6 %	12 %	8 %	2 %	1.5 %	28.9 %
5	Chandigarh	52 %	6 %	7 %	4 %	1 %	-	28 %
6	New York	43.1%	26.1%	15%	-	4.1%	4.9%	6.8%
7	Berlin	26.9%	36%	-	-	14%	-	6%
8	Rio de Generio	54.4%	17%	17.9%	-	3.1%	1.9%	5.7%
9	Abuja	63.6%	9.7%	8.7%	1.6%	2.6%	3.2%	10.6%

Source: Compiled by the Authors

Chemical Composition of Waste

It is not uncommon for waste materials to contain trace amounts of various minerals, including potassium, phosphorus, calcium, manganese, and iron. The specific amounts of these minerals present in waste materials can vary significantly depending on a variety of factors, including the source and composition of the waste and the processing or treatment it has undergone.

Potassium is a common element widely distributed in the Earth's crust and often found in small proportions in waste materials. Iron is a common element in various minerals, including hematite, magnetite, and limonite. Chemical composition determines many things in waste management. The pH of Varanasi waste is on the acidic side, while Indore's is normal (Table 2). The acidic nature of the waste makes it unfavourable for its composting. It also affects the nature of the soil where it is dumped, especially if the dumping site is illegal or not prepared according to the norms and statutory regulations (Nakasaki et al., 1993; Srivastava et al., 2020).

It is important to note that the presence of these minerals in waste materials does not necessarily mean that they pose a risk to human health or the environment. However, it is vital to properly manage and dispose of waste materials to minimise the potential for negative impacts on the environment and human health.

Table 2: Chemical Composition of Varanasi and Indore

	Varanasi	Indore
Moisture Content	34.72%	33.37%
Ph	6.37	7
Potassium	0.07 gm/kg	0.04 gm/kg
Iron	0.512 gm/kg	0.22 gm/kg
C: N Ratio	19.4	29.3

Compiled by the Authors

Moisture and C:N Ratio for Organic Waste

Moisture content refers to the amount of water present in a material. It is typically expressed as a percentage of the total weight of the material. The moisture content of a material can affects its physical and chemical properties, and it is often an essential factor in processes such as drying, combustion, and decomposition (Magrinho & Semiao, 2008). Moisture content affects many vital parameters like calorific value. Calorific value is crucial as it determines how good a particular material is as fuel; if a material's

calorific value is higher, it will generate more energy for combustion (Komilis et al., 2014).

The carbon-to-nitrogen ratio (C:N ratio) measures a material's relative amounts of carbon and nitrogen. We often use it to predict the decomposition rate of organic materials, such as plant matter, manure, and food waste (Bernal et al., 2009). A lower C: N ratio means more nitrogen than carbon, indicating that the material will decompose more quickly (Gao et al., 2010). A higher C:N ratio means more carbon than nitrogen, indicating that the material will decompose more slowly. The optimal C:N ratio for composting is generally between 25:1 and 30:1(Bishop, 1983). By analysing the C:N ratio of Varanasi and Indore, it is evident that Indore has a C: N ratio in the bracket of 25- 35, which is reckoned to be a good candidate for composting. Looking at Table no 2, it is evident that Varanasi waste lags in this as it has a C: N ratio of 19. Manipulation can make it suitable for composting. This can be a probable reason for better organic waste management in Indore because organic waste comprises approximately 50% of the total waste. If we manage it adequately, half of the waste problem will be sorted automatically. The goal is not to decompose the organic material but to make quality compost. This problem prevails in many states because organic waste is converted into compost. However, because of inferior quality, farmers are reluctant to use it in their fields.

Cleaning Collection and Transportation in Varanasi and Indore

Solid waste management is a critical issue in cities worldwide, including Varanasi and Indore in India. It is essential for public health, sustainable development, environmental protection, and a city's overall quality of life.

In Varanasi and Indore, solid waste is collected and transported to designated landfill sites for disposal. The Varanasi Municipal Corporation is responsible for solid waste collection and disposal. In Indore, Indore Municipal Corporation is responsible for the solid waste management. In some cases, private companies may also be willing to provide solid waste management services. For example, Varanasi IL&FS Environmental Infrastructure and Services Limited is a private entity that sweeps sanitation and solid waste management in 84 wards, including wards adjoining Ganga ghats. Kiyana Solutions is responsible for sweeping and door-to-door collection in 30 wards in partnership with Varanasi Municipal Corporation. Organic Recycling Systems Private Limited operates Varanasi's three waste-to-energy plants, including the Bhavania Pokhari and Adampur waste-to-energy plants. Ankur Scientific handles waste-to-energy operations in the Karsada waste dumping and management plant. Similarly, Indore city A2Z infrastructure collects waste from bins and transports it to the open dumping ground (Varanasi Municipal Corporation,2019, Solid Waste Management Plan).

Effective solid waste management involves a range of activities, including:

- **Cleaning:** It includes sweeping and primary collection of garbage from streets, roads and residential areas.
- **Collection:** Solid waste is collected from homes, businesses, and other sources using specialised vehicles, such as garbage trucks.
- **Transportation:** The collected waste is transported to designated landfill sites or other facilities for processing and disposal

Varanasi, having the tag of the oldest continuous living city in the world, comprises narrow lanes and streets, which makes cleaning and collection an arduous task. Conversely, Indore is a comparatively newly built city with a robust network of wide roads and pedestrians. Varanasi started its capacity building after 2015, while Indore began working on its waste management infrastructure in 2009. The lag in infrastructure is evident in Table 3 in almost all the categories. Indore is leading Varanasi except in hand carts. Due to its narrow lanes and street culture, hand carts are more prevalent in Varanasi due to its tag of being the oldest living city in the world. The workforce is also a problem in the case of Varanasi as it needs more manual workers than Indore because of its inherent rural mindset,

which differs from Indore (CBUD Final, 2015, City Development Plan). Varanasi also suffers from a workforce crunch as recruitment is done at the state level. Varanasi Municipal Corporation cannot afford a larger workforce as a money crunch is common among almost all the ULBs (Urban Local Bodies) in India. Varanasi has 38 Safaai supervisors against the need for 108, which explicitly indicates the workforce shortage in Varanasi. Indeed, Varanasi has more organic waste than Indore, but Indore manages it more efficiently. One reason behind this may be that the C: N ratio of Indore is better than that of Varanasi. So, composting is more accessible in Indore's organic waste. Secondly, due to the reasons mentioned above, Indore can make quality compost. Quality compost, in turn, makes the process of organic waste compost a much more economically viable option. If compost quality is not good, farmers will be reluctant to use it in their fields. There is already a barrier of thought that compost made of organic waste might not be as suitable as usual compost made from cow dung.

Cities need to implement effective solid waste management systems to ensure that waste is properly collected, transported, and disposed of and to minimise the negative impact on public health and the environment (TERI, 2019, Assessment Report).

Table 3: Comparative Data of Cleaning Collection and Transportation in Varanasi and Indore

	Varanasi	Indore
Door To Door Collection	**75%**	**100%**
Mechanical Sweeping	**8%**	**15%**
Manual Sweeping	**92%**	**85%**
Waste Collection Vehicles (Small & Medium)	**178**	**470**
Bulk Waste Trucks	**58**	**78**
Rickshaw Trolley	**717**	**350**
Segregated Waste Transport	**50%**	**100%**

Compiled by the Authors

Transfer and Treatment in Varanasi and Indore

Indore and Varanasi are cities in India that are known to have significant solid waste management challenges. In both cities, the primary method of solid waste collection and disposal is through landfills, although efforts are underway to improve waste segregation, recycling, and composting (Rai et al., 2017).

The leading landfill site in Indore is located at Devguradia, which is managed by the Indore Municipal Corporation (IMC). The IMC also operates several transfer stations, where solid waste is collected and transferred to the landfill for disposal. In recent years, the IMC has also implemented several initiatives to promote waste segregation, including distributing green and blue bins to collect biodegradable and non-biodegradable waste, respectively (Singh, 2021).

In Varanasi, the primary landfill site is located at Karsada, managed by the Varanasi Municipal Corporation (VMC). The VMC also operates several transfer stations, where solid waste is collected and transported to a landfill for disposal. Like Indore, Varanasi has also implemented initiatives to promote waste segregation, including distributing green and blue bins and establishing community composting centres (Tripathi, 2018)

Overall, Indore and Varanasi face significant challenges in managing their solid waste, including improving waste segregation and increasing recycling and composting. However, ongoing efforts are also being made to address these challenges and improve both cities' solid waste management systems. As we have already discussed above, Indore has a suitable C: N ratio; this effect is evident from Table 4. Indore is composting 93%, while Varanasi has managed to do only 50% of composting operations.

Table 4: Transfer and Treatment Facilities in Varanasi and Indore		
	Varanasi	**Indore**
Sanitary Landfills	**1**	**2**
Digesters	**3 units**	**2 units (7%)**
Composting Operations	**50%**	**93%**
Waste Transfer Points	**27**	**36**
Pyrolysis Plant	**1 (400 MT/month)**	**1(600 MT/month)**
Compiled by the Authors		

Relation between Economic Prosperity and Waste Generation

After the economic reforms in 1991, India is on the path to steady economic growth. LPG (liberalisation, privatisation and globalisation) reforms significantly influence India's economic prosperity. As a result, consumerism has increased many folds, increasing solid waste generation.

First of all, we will have a look at Indian states in which manner urbanisation, consumerism and waste management are related. Looking at Figure 2, we can decipher that most states follow the trend of having more waste per capita with the increase in per capita GDP. Only two states, Sikkim and Goa, exhibit some divergence from this trend due to their massive tourism-based economies, which are largely driven by consumerism-based tourism.

Patterns from various Indian cities reveal the relationship between economic growth and waste generation. Some cities, like Indore, deviate from this pattern. Many factors are responsible for this phenomenon. One of the major factors is reducing waste generation.

Patterns from various Indian cities reveal the relationship between economic growth and waste generation. Usually, more GDP per capita leads to more waste generation. Some cities, like Indore, Ahmedabad, and Chandigarh, are deviating from this pattern, increasing their GDP per capita but decreasing waste generation per capita, as shown in Figure 3. Many factors are responsible for this phenomenon. One significant factor is reducing waste generation.

Policy Road Map of World Bank for Waste Management and Status of India

Many agencies work on solid waste management, including the World Bank, which has prepared a roadmap for waste management. Below is a detailed analysis of where India stands according to the World Bank's roadmap.

Step 1. Identify and authorise an organisation for leadership and reforms

As formulated by the World Bank and the Ministry of Environment, Forests, and Climate Change in India, the Ministry oversees the country's waste management policies. Then, the Central Pollution Control Board (CPCB) sketches national guidelines for database management and draws a clear definition of waste management (see, 2016, 2021).

Step 2. To initiate ample incentives and regulatory oversight

Governments should incentivise those states or local bodies that are performing well in waste management. India lacks in this type of arrangement. Private entities are encouraged by giving some relaxation for waste treatment facilities, but on the level of civic bodies, incentives are missing.

Step 3. Set up a permanent programme for key stakeholders to engage in dialogue

To establish such an umbrella permanent platform where all stakeholders, such as the Association of Municipalities, Finance Ministry, Ministry of Environment, Statistical Department, Environment Protection Agencies, NGOs and Civil Society Organisations working in this field should come together for consultation and

broad policy discussions. India lacks such a permanent platform. Although some organisations are there, like the Centre for Science and Environment (CSE) and the National Solid Waste Association of India (NSWAI), are trying to do this work, they lack government representatives. Therefore, this type of platform will only gain momentum in India if the government establishes it or provides its backing.

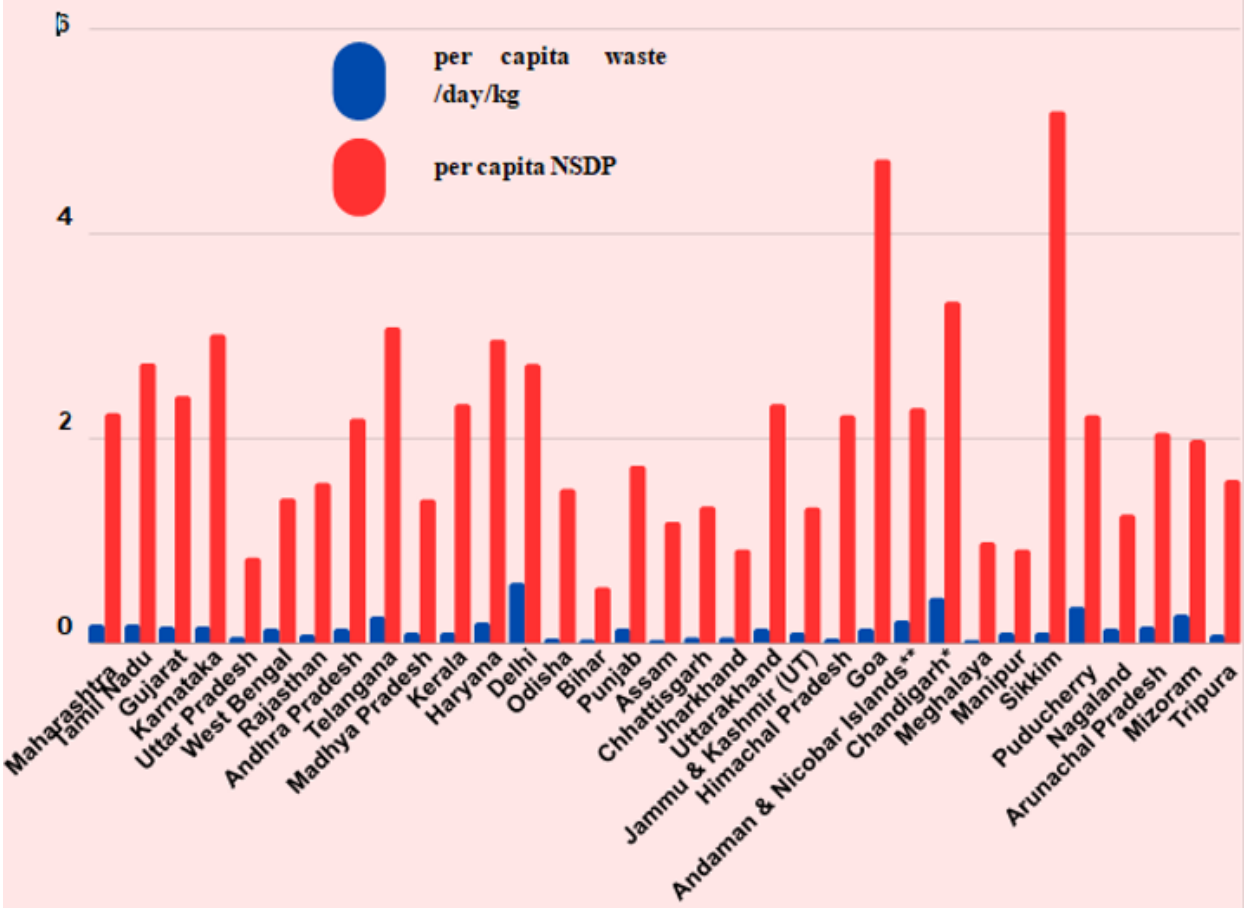

Figure 2: Waste Generation per capita and per capita NSDP (Net State Domestic Product) of Indian states.
Source: Compiled by the Authors

Step 4. A national-level strategy for waste management

India has meticulously implemented the Swachh Bharat Sarvekshan to collect waste management and sanitation data. This practice has been in place since 2016. Even going one step ahead, India is functioning on different levels and imparting a sense of healthy competition between cities to do better in the fields of waste management in particular and sanitation in general.

Step 5. To take forward institutional refinement at the local level

India has also done very well in this field. The respective State Environment Ministries prepare state-level strategies, and the Housing and Urban Affairs Ministry helps by charting the waste management plan right from the start of any housing project. Waste management plans are gaining momentum on the municipality level.

Step 6. After the establishment of a primary waste management system, find out the sector which can perform very well

In this field, there is a lot to do on every level. India has full-fledged waste management systems from collection to separation to treatment to disposal in metropolitan cities with no 100% collection and separation and treatment facilities. They should first ensure

100% collection and segregation; without this, much waste will end up in landfills that are in unplanned landfill sites.

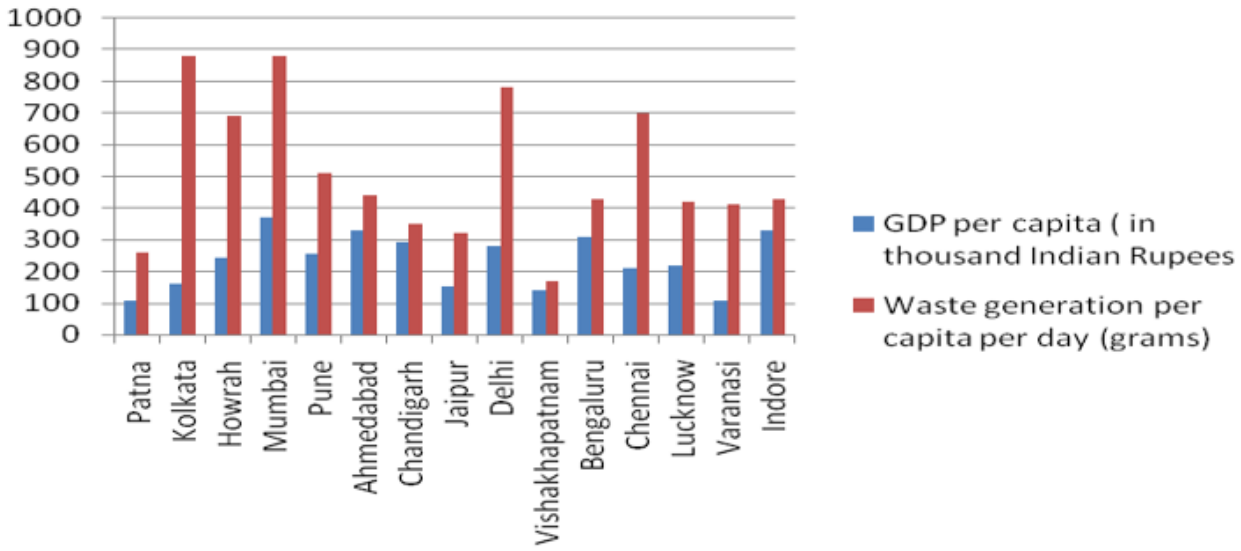

Figure 3: Waste Generation and per capita GDP of Major Indian cities
Source: Compiled by the Authors

Step 7. Waste management fee and assessment of fee structure

A fee should be charged for waste management. There should be a proper analysis for optimum fee structure so that the cost incurred can be recovered, and the excess fee should not burden the public. Delhi has charged fees from bulk generators since 2020 (it is in line with the Solid Waste Management Bylaws 2017, which came into effect on which came into effect from 15 January 2018). Chennai started charging fees but rolled it back. Indore is collecting INR 60-150 from the residents. Tirupati is collecting INR 40-60 from the households. Pune charges INR 55-150 from households and commercial establishments. Many civic bodies are preparing to levy waste management fees.

Step 8. After commissioning the operational collection and disposal system, the focus should be on segregation. That should be done at an advanced level for different types of plastic, glass, e-waste, etc.

First, a survey of the recycling market should be done. Based on the monetary value recyclables can achieve, sorting infrastructure should be commissioned. This will make waste management more economically viable. India lags in such a holistic and economically viable policy. Sorted materials at source will also increase transportation costs. Vehicles with different compartments for sorted materials will be needed, and designing such vehicles will add cost. India has many decentralised awareness programmes for separation at source. The awareness programme should have a feedback mechanism in place.

Step 9. Segregation of organic waste at the source

Organic waste is a good source of methane used as fuel. India is taking significant strides in this field. Organic waste is easy to handle if appropriately segregated. The best way to achieve segregation is at the source. Some cities like Indore are putting forward a good example of segregation at source.

Step 10. Focus on treatment processes like pyrolysis and incineration

It is an expensive option. India is considering it as it reduces plastic waste, a giant menace. The share of TSR (thermal substitution rate) used in the cement industry in India is 4%, out of which the share of RDF (refuse-derived fuel) is only 1% when compared to the EU. EU (European Union)

successfully achieved 40% of TSR (out of which 26% is from waste and 14% from biomass). Austria, Netherlands, and Germany use RDF in the cement industry, which accounts for 60-70% of total coal consumption. India has an ambitious target of 25% of TSR by 2025(on 05 June 2018, World Environment Day). In SWM rules 2016, the goal of 5% RDF utilisation from a 100 km range of cement plants was in place. It cannot be achieved for various reasons, such as the quality and availability of RDF.

Step 11. To keep the sector on track, regular monitoring, assessment, and a dynamic policy framework with economic incentives are needed.

India has institutions in place that regularly monitor and do the course correction. The CPCB mainly does it. However, India is lagging when it comes to specialised staff for dynamic policy-making and assessment. Government officials at the top level are not specialised in waste management subjects, and unfortunately, they are solely responsible for policy making. Some exceptions exist, like IIM Indore, which is now training top officials in waste management through its specialised centre named ANVESHAN (Kaza et al., 2018).

Policy Intervention and Gaps of Varanasi and Indore for Global Waste Management Policies

- Organic ways should be in focus as they comprise significant solid waste. There should be a focus on the economic viability of the process used for waste disposal; for example, composting is a prevalent method to mitigate organic waste. But considering the government policy to popularise ethanol blending, we should divert the organic portion towards ethanol production. It is an economically and environmentally viable option as ethanol creates less pollution than other ways to energy products. It is also a good option as government policies focus more on flex-engine automobiles. The process involved in producing other waste-to-energy products is tedious and not environmentally friendly.
- Waste-to-energy options, such as incineration, will be of great use when the opportunity for ethanol production is unavailable. Ways to energy production is a much more economically viable option for a country like India, which imports around 9.5 billion of energy from outside the country.

If you go into the policy level, then on the state level in Uttar Pradesh, ULBs have a population of less than 100,000, and between 100,000 and 1000000, they still have two bin systems. Two-bin systems cannot be a good choice because the level of segregation decides the fate of waste. If segregation is in more categories, then it is better to handle that waste. There are many directions related to handling waste by private entities or on the PPP model for better management. According to the policy documents, NGOs and rag pickers should be involved in the process, but it is only in policy documents. There is clear direction over RDF that if ULBs cannot process it, then private entities should be roped in. Similarly, inert waste or the waste that is going to landfill site should not be more than 10% of the total waste.

The focus should be more on decentralised waste management, and it should be cost-effective as well. ULBs were instructed to make bylaws for the prohibition of littering and burning waste and the segregation of waste in the best possible way.

In the case of Varanasi and Indore, Varanasi started late in this race of waste management. Even before core policy formulations in Varanasi, Indore bagged first place in Swachh Bharat Sarvekshan in 2016. Since 2016, Indore has evolved its waste policies very quickly. Some of the central policy-level interventions that are evident in good waste management in Indore are as follows:

- Live tracking and monitoring of garbage trucks for effective routing and supervision started in 2017 in Indore. Varanasi has also started this with a dedicated command centre.
- Separate mechanism for bulk waste generators. Making tailor-made

solutions and avoiding a one-size-fits-all policy.

- The Aadhaar-linked biometric attendance system for workers employed in the waste management division facilitates better human resource management.
- Surprise visits by public representatives like the Mayor and Members of Legislative Assemblies (MLAs). Senior officers also visit the scene daily to assess the situation.

There are other reasons for the success of the Indore model, including more effective policy implementation. For example, every city has banned plastic bags, but Indore has successfully implemented this ban by restricting end-users and targeting retailers and producers. Indore also took intense action by seizing large quantities of plastics from producers and retailers.

Conclusion

The central aim of this study was to critically analyse and compare the Solid Waste Management scenarios of Indore and Varanasi while probing the policy gaps and possible interventions. Varanasi city lags in waste management in many areas compared to Indore. Primarily, Varanasi city lags in segregation. Besides segregation, Varanasi catches up with Indore in all waste management measures. The collection is almost 95% to 100% in Varanasi City. When Varanasi catches up in the segregation field, it will quickly monetise and manage its waste. The economic viability of waste is an extensive parameter in waste management. Based on the findings of our study, we make some recommendations for improving Varanasi City's Solid Waste Management.

A proper and strict policy should enforce waste segregation at the source of generation. Those in the lower socio-economic strata can be offered monetary benefits to promote waste segregation. The public in the upper strata can be dealt with fines or strict enforcement laws.

A more decentralised collection can be a better choice as Varanasi has a very mixed population in terms of socioeconomic indicators, culture, and regional aspects.

Due to Varanasi's street culture, conducting proper research on which areas require which type of vehicle can significantly enhance the transportation system's robustness.

More emphasis on awareness: new means can be deployed to convince the public. We need to utilise popular means of communication, such as smartphones, more effectively by posting and circulating YouTube videos, which are increasingly popular for information and education on solid waste management.

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Ethical Approval and Conflict of Interest

This study does not require ethical approval as human case studies are not involved. Further, there is no conflict of interest between the authors regarding the publication of this study.

Informed Consent

Government officials involved in waste data collection were informed about the procedure, objective, and use of data. The language barrier was not a problem, as officials were highly educated. Proper briefing was done to ensure data use and develop a sense of confidence in officials.

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Author Contribution

Deepak Rathore: Conceptualisation; writing— original draft; review and editing.

Ravikant Dubey: Writing—review and editing.

R S Singh: Supervision; writing— review and editing.

Amrita Dwivedi: Supervision; writing—review and editing.

About the Authors

Deepak Rathore is a research scholar at the Department of Humanistic Studies, IIT (BHU) Varanasi. He has obtained his Master's degree in Science from Banaras Hindu University in Biochemistry and his Master's degree in Technology from Delhi Technological University in Biomedical Engineering. He has worked on a wide range of topics, including neurodegeneration and tissue engineering. Currently, he is working on solid waste management and the occupational health hazards faced by rag-pickers. He has authored or co-authored articles in reputable journals and book chapters in prominent publication houses, including Springer and Elsevier.

Mr. Ravikant Dubey is a Research Scholar at the Department of Humanistic Studies, IIT (BHU) Varanasi. He obtained his Postgraduate Degree in "Environmental Science and Technology" from Banaras Hindu University, Varanasi, India, and his Undergraduate Degree in "Life Sciences" from V.B.S. Purvanchal University, Jaunpur, India. Mr. Dubey has a keen interest in municipal solid waste management and the circular economy, with a focus on Socio-Technical Aspects. He has experience as a Project Assistant in two projects on "Sustainable Solid Waste Management in the IIT (BHU) Campus." He has published several research articles and chapters on "Waste Management" in reputable academic journals and has presented his work at numerous national and international conferences.

Professor Ram Sharan Singh obtained his B.Tech. (H.B.T.I. Kanpur), M.Tech. (IIT Kanpur), Ph.D. (Chem. Eng.) degree from IIT (BHU). He began his career as a Lecturer at BITS, Pilani, in 1999, was promoted to Professor in 2015, and was further promoted to Professor (HAG) in 2022 at IIT (BHU). Prof. Singh has supervised 59 M.Tech./MD and 22 Ph.D. theses, authored/co-authored/presented over 200 technical papers with a total impact of over 1300, one book and eight book chapters and completed projects sanctioned by ISRO, DRDO, MoEF, DST, MHRD, etc. He also made significant contributions to the Institute and University administration. He is the

recipient of several Awards and Honours like Rastriya Fertilizer and Chemical Award by Fertilizer Association of India, Publication award by IIT (BHU) Global Alumni Association and Fellow by Biotech Research Society of India (BRSI) and Institute of Engineers (India), Chair Professor by Bureau of Indian Standards (BIS).

Dr. Amrita Dwivedi obtained her PhD from Banaras Hindu University, India, and pursued postdoctoral research in the Civil Engineering Department of the Indian Institute of Technology (IIT) BHU, Varanasi. She is currently an Assistant Professor in the Department of Humanistic Studies at IIT (BHU) Varanasi. Her research interests focus on the field of environmental studies, especially in sanitation and health, waste management, housing and hygiene. She has also supervised six M.Sc. theses. She is a reviewer for various journals, including the Journal of Water, Sanitation and Hygiene for Development and Waste Management & Research (WM&R), among others. She has developed undergraduate and postgraduate courses. She has published 15 research papers in refereed journals, 07 in Conference Proceedings, 07 Book Chapters, and 03 Books.