SUSTAINABLE MANAGEMENT OF SOLID WASTE: A CASE STUDY OF INDORE

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Submitted by

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INDIAN INSTITUTE OF PUBLIC ADMINISTRATION

NEW DELHI

Certificate

It is hereby declared that this submission is my original piece of work and to best of my knowledge and belief, it contains no material previously published or written by any other person. I am aware of the University's norms and regulations regarding the plagiarism including the disciplinary action that it may invite. Any use of the works by any another author, in any form, is adequately acknowledged at their point of use or in the Bibliography.

Date: March 2024
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Certificate

I have the pleasure to certify that ***Air Commodore Devashish Kukreti*** has pursued his research work and prepared the present dissertation titled ***'Sustainable Management of Solid Waste: A Case Study of Indore,'*** under my guidance and supervision. The same is result of research done by him and to best of my knowledge; no part of the same has been part of any monograph, dissertation or book earlier. This is being submitted to the Panjab University, Chandigarh, for the purpose of Executive Masters Degree in Public Administration and Public Policy in partial fulfillment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of ***Air Commodore Devashish Kukreti*** is worthy of consideration for the award of Executive Masters degree of the Panjab University, Chandigarh.

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List of Abbreviations

C&D	-	Construction and Demolition
CNG	-	Compressed Natural Gas
CO2	-	Carbon di Oxide
CPCB	-	Central Pollution Control Board
CSI	-	Chief Sanitary Inspector
D2D	-	Door to Door
D/GPS	-	Differential/ Global Positioning System
E-Waste	-	Electronic Waste
FB	-	Fluidized Bed (Combustion Process)
GTS	-	Garbage Transfer Station
GI Pipes	-	Galvanized Iron Pipes
IEC	-	Information Education Communication
IMC	-	Indore Municipal Corporation
ICCC	-	Integrated Command and Control Centre
ISCDL	-	Indore Smart City Development Limited
LFG	-	Land Fill Gas
MASS	-	Mass Fired Combustion System
MRF	-	Material Recovery Facility
MSWM	-	Municipal Solid Waste Management
MSW	-	Municipal Solid Waste
MTPD	-	Metric Tonne per Day
MP PCB	-	Madhya Pradesh Pollution Control Board
MOHUA	-	Ministry of Housing and Urban Affairs
NEERI	-	National Environmental Engineering Research Institute
NGOs	-	Non Governmental Organisation
NITI Ayog	-	National Institution for Transforming India Ayog
OWC	-	Organic Waste Converter
PIL	-	Public Interest Litigation
PPP	-	Public Private Partnership
RDF	-	Refuse Derived Fuel
RFID	-	Radio Frequency Identification
RWA	-	Resident Welfare Association
RCC	-	Reinforced Concrete Cement
SBM	-	Swachh Bharat Mission
SO2	-	Sulphur di Oxide
VGF	-	Viability Gap Funding

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Executive Summary

Prime Minster of India launched the Swachh Bharat Mission (SBM) 1.0 on 02 Oct 2014 as a national movement to promote cleanliness, sanitation and proper waste management to be achieved by the year 2019 throughout the country. SBM 2.0 was launched on 01 Oct 2021 with the objectives of making all cities garbage free by year 2026 while maintaining open defecation free status. Cities were assessed as per the swachh sarvekshans and rated on the performance as per the markers of SBM 1.0 and 2.0.

This study dwells into the management of municipal solid waste in Indore city that transformed the city from being 149th in 2015 swachh sarvekshan to being the cleanest city of India in 2017, a position that the city has retained for seven years in a row. Additionally, Indore was awarded seven star garbage free rating in the year 2023. Indore Municipal Corporation (IMC) has been the chief architect of transformation of the city, from one struggling with MSWM to being the cleanest city of India. The study of MSWM in Indore is unique as it displays strong will, political-executive co-ordination, incorporation of technology and above all participation by people or *Jan Bhagidari*.

The city of Indore generates 1174 MTPD of solid waste. Indore Municipal Corporation (IMC) has revolutionized the collection, transportation and processing of the generated solid waste. IMC has incorporated numerous innovative means and technology in every step of MSWM such as collection, transportation and processing. These new steps were initiated by IMC in a pilot project in year 2016 and were later expanded to the entire city. With strict control and monitoring by an Integrated Command and Control Centre (ICCC), IMC has been able to ensure efficiency in collection and transportation of the waste. The commissioning of waste to energy plants on PPP model have addressed waste disposal and also created revenue for the IMC. Bio CNG generated from the wet waste processing plants is used by the IMC buses and the RDF produced from the dry waste processing plants is used by cement factories and power plants as fuel. The present dry and wet waste processing capability has been achieved over a period of three to four

years since 2016. With the current (2023) processing capability of 585 MTPD of wet waste and 400 MTPD of dry waste, Indore is able to successfully process 100 % of its waste. These steps have ensured that no waste is dumped at the landfills. Additionally, Bio Remediation of 30 Lakh tons of legacy waste at Devguradia landfill site has been completed and 100 acres of land has been reclaimed. By this, Indore has achieved zero waste and zero landfill.

The population of Indore city is expected to grow at a rate of 3.2 % per annum. It is expected that the population would be 30 Lakhs by 2025 and 37.5 Lakhs by 2031. With increase in population, the MSW is likely to increase from 1174 MTPD in year 2023 to 1665 MTPD in 2031 at a rate of 1.33% per annum. This increase in MSW would challenge the existing setup of MSWM and processing capability. Therefore, capacity and capability of MSWM in Indore needs to be increased along with continued innovations and infusion of technology to ensure sustenance in future.

In 2023, Surat was second cleanest city and Navi Mumbai was assessed as third cleanest city in India. Other cities are also improving their swachh sarvekshan ratings. However, the study of Indore model of MSWM is unique due to the short time span in which they have been able to transform the city from one struggling with MSWM to one with seven star garbage free rating and seven times cleanest city in a row. The city has now aimed at being zero waste and zero landfill city.

Chapter 1

Introduction

1.1 Background

Over the years there has been a continuous migration of people from rural and semi urban areas to towns and cities. As per 2011 census, 68.8 % of population resides in rural areas and 31.2 % resides in urban areas[1]. The continuous influx of population to the cities poses a major challenge for the municipal councils/ corporations towards providing basic amenities, services, sanitation and waste management. The amount of per capita solid waste generated in small, medium and large cities in India is estimated as 0.1 kg, 0.3 to 0.4 kg and 0.5 kg per day respectively[2]. As per the study carried out by National Environmental Engineering Research Institute (NEERI), per capita waste generation rate increases as per size of the city and varies between 0.3 to 0.6 kg/day in the metropolitan areas. The estimated annual increase in per capita waste quantity is about 1.33% per year[3]. Earlier, disposal of Municipal Solid Waste (MSW) was by means of dumping at the landfill sites. This resulted in huge piles of waste. With advent of new methods, processes and technology, MSW can be efficiently managed by recycling, converting to compost or converting into energy. Agencies responsible for MSWM need to continuously incorporate new scientific methods, processes and technology to manage the MSW efficiently and in an environment friendly scientific manner. Unscientific methods employed for disposal of MSW would result in environmental pollution and cause health problems[4].

1.2 MSWM in India

Municipal Solid Waste Management MSWM is one of the most neglected topics of Urban Development in India. As per the Indian Constitution, SWM is the responsibility of the State Governments. These activities are handed over to the Municipal

Corporations/ Councils through state legislation. These bodies perform the processes of collection, segregation, transportation, processing and disposal of MSW. With increasing population in urban areas, there is increased load on the civic bodies of provisioning services like water supply, electricity, roads, education, sanitation and MSWM. On an average the civic bodies spend approximately 5% - 25% of their budget on MSWM. Notwithstanding the amount spent, the state of MSWM in most of urban areas including the national capital region is abysmally low with threat to public health as well as environmental quality[5]. With the launch of Swachh Bharat Mission (SBM) 1.0 & 2.0 there has been a transformation in sanitation and waste management since 2014[6]. Further, MSW processing in India has increased from 17 % in year 2014 to 75 % in 2023. The D2D collection of MSW is 100 % in 97 % of the wards. Segregation of waste at source is being undertaken at almost 90 % of the wards throughout the country[7].

1.3 Challenges of MSW in Indore

As per the 2011 census, Indore city (sub district Indore- Urban) has 446056 households with a population of 2193664[8]. The growth of the population since then has been at a rate of 3.2% since 2020[9].With this growing population the volume of garbage grew from 750 MTPD in 2011 to 900 MTPD in 2017[10]. The MSW is reported to be 1174 MTPD in the year 2023.

The city was facing major challenge of MSWM prior to 2016. Collection of garbage from households was not proper and the Solid Waste Management was carried out in three stages. Primary Collection was done in some localities by municipality workers and in other by private arrangement employed by the hosing colonies themselves. The collected household garbage was dumped at selected locations of secondary dustbins in the city. The city had a total of 1380 dustbins where the collected garbage was dumped. This led to these dustbins overflowing with waste and leading to foul smell as well as the area around the dustbins became littered with waste. The secondary collection from the dustbins was undertaken by a private contractor (A2Z Infrastructure limited) and the collected garbage was then dumped at the dumping ground

at Devguradia. The collection by A2Z Company was not adequate due to various reasons from maintenance of their vehicles to financial woes of the company leading to accumulation of waste and overflowing of the dustbins. The combination of poor collection and transportation of household waste gave a filthy look to the city[11]. Owing to numerous complaints the contract with the A2Z Company was terminated in 2015. In the year 2014, the IMC came under immense pressure due to PILs filed in the State High Court for the civic body's inability to deal with MSW resulting in severe environmental issues and unsanitary conditions leading to public health implications[12]. Additionally the SBM drive started in 2014 and the rating system of cities would have also put additional pressure on the Municipal Corporations to address these long pending issues.

1.4 The turning Point: SBM and Indore

Prior to 2016, Indore struggled with MSWM and was ranked 149th in the 2014 survey. The situation improved to 25th position amongst 73 cities in 2016 survey[13] . The year 2016 was the turning point for Indore and from a city that struggled with MSWM it emerged as the cleanest city of India for seven times in a row in the year 2023.[14]. Indore was felicitated by President of India in 2022 for being the first 7 star garbage free city of India[15]. The city with population of over 3.2 million, (Indore District Urban) generates around 1,100 metric tons of waste on a daily basis[16]. IMC has undertaken some very innovative steps and followed them up with perseverance incorporated high end technology for collection, transportation and processing of MSW. With perseverance of IMC and active involvement of the citizens, the city has emerged as a shining example of effective waste management in India. The efforts of IMC have been well recognised as it was awarded the PM excellence award in 2020 for SBM (Urban) under the Jan Bhagidari Scheme[17].

1.5 Rationale for Study

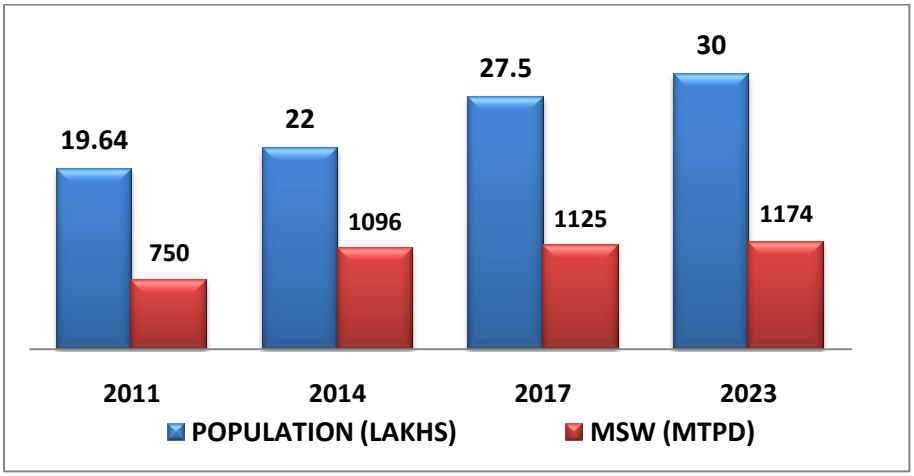
The launch of Swachh Bharat Mission in 2014 and its markers propelled various Indian cities including Indore to take a relook at the various markers of SBM. These included management of solid waste, elimination of open defecation, eradication of manual scavenging, awareness & behavioural change and capacity development of the Municipal bodies[18]. Many cities in India have population, budget, area and even waste generation similar to that of Indore. Performance of Indore from being a city struggling with MSWM prior to 2016 to the cleanest city of India for seven years in a row is commendable. What makes the achievement of Indore unique as compared to other cities is the short duration of time in which it has addressed the issues of MSWM and has emerged at the top. The

This case study is being undertaken to understand as to how IMC has been able to transform Indore in a short time from being a city struggling with MSWM to the cleanest city of India. In this study, an attempt has been made to provide a comprehensive review of MSWM of Indore city to understand the challenges, planning, execution, innovations, role of technology as well as participation by people in the success of the SBM (U) scheme. The study also aims to understand if the existing practices and methods would be adequate for sustainable management of MSW in the future.

1.6 Statement of the Problem

IMC has put in innovative efforts to emerge as the cleanest city of India by addressing various issues related with MSW management and attained 7 star garbage free rating. However, the challenge of MSWM would always remain as the MSW generation in urban areas would continue to increase with increasing population, increasing purchasing power and increasing consumption. The growth of population of Indore along with MSW generation is given at Figure 1. Therefore, sustenance of the present practices of MSWM for future remains a challenge.

Figure 1: Population and MSW Generation in Indore



Source: Indore Municipal Corporation & Indore Town Population Census 2011-2024 (https://www.census2011.co.in/data/town/802273-indore-madhya-pradesh.html)

New villages and sub urban areas would continue to be added in the municipal limits of the city. Therefore, MSWM needs to be extended to these new areas to ensure efficiency. With steady migration of population from rural to urban areas and expansion of the city itself, the challenge of sustaining the present effort remains. Further, new technologies of waste management need to be incorporated to ensure efficient and cost effective management of waste for future sustainability.

Some of the key aspects that need to be looked into are the synergy that existed at every level, leadership role played by key officials and elected representatives of IMC, participation by people of Indore in the cleanliness drive, incorporation of technology to enhance efficiency, IEC campaign leading to behavioural changes and Jan Bhagidari by the residents of Indore.

Chapter 2

Review of Literature

2.1 Increasing MSW in Cities

The World bank in its 2018 report titled, What a Waste 2.0, "A global Snapshot of Global Solid Waste Management to 2050", brought out that the global waste generation will increase from 2.01 billion tonnes in 2016 to 3.40 billion tonnes in 2050. In the Indian context of MSW generation, the report of Planning Commission in 2014 stated that Urban India generates 62 million tonnes of MSW every year. It also predicted that this volume of waste would further increase to 165 million tonnes by 2030. Table 1 shows the major cities in India and their per capita waste generation (2010-2011). Population data has been taken from the 2011 census and the waste data from CPCB report of 2011.

Table 1: Prominent cities – Population Vs MSW generation

City	**Population (2011) (million)**	**Total Waste TPD**	**Kg per capita per day**
Ahmedabad	6.3	2300	.36
Hyderabad	7.7	4200	.54
Bangalore	8.4	3700	.44
Chennai	8.6	4500	.52
Kolkata	14.1	3670	.26
Delhi	16.3	5800	.41
Mumbai	18.4	6500	.35

Source: Biswas, D and Roy NC (2018) Municipal Waste Management: Issues and Challenges

India generates approximately 1,33,760 tons of MSW per day, of which 9,19,152 MTPD is collected and 25,884 MTPD is treated. MSW generation per capita in India ranges from 0.17 Kg in small towns to 0.62 Kg in big cities. Table 2 shows the per capita waste generation variation as per the population of the cities.

Table 2 : City population Vs Per capita waste generation

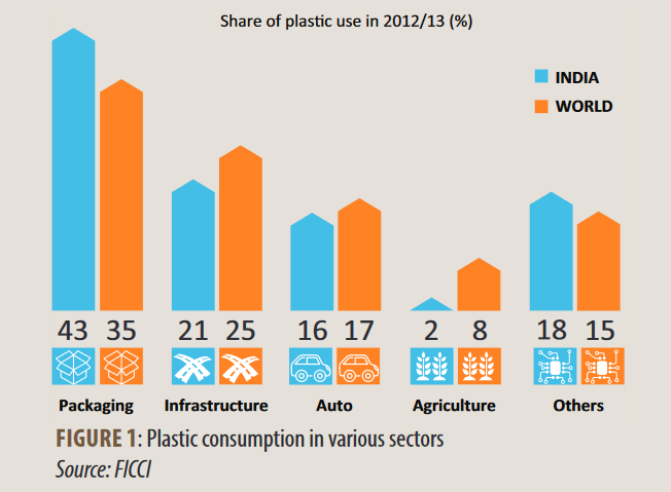
Population of the city	**Waste generation Per capita per day (kg)**
< 0.1 million (8 cities)	0.17 to 0.54
0.1 to 0.5 Million (11 Cities)	0.22 to 0.59
1million to 2 million (16 Cities)	0.19 to 0.53
> 2 million (13 Cities)	0.22 to 0.62

Source: Biswas, D and Roy NC (2018) Municipal Waste Management: Issues and Challenges

The authors (Biswas, D & Roy NC) estimate that waste generation in urban areas would become 0.7 kg per capita per day by the year 2025 and rate of increase of MSW per year is stated as 5%[19].

2.2 Increasing Plastic Content in MSW

Figure 2: Plastic consumption in various sectors



Source: Bhattacharya, et al. (2018) Challenges and Opportunities Plastic Waste Management in India

As can be seen from Figure 2, maximum consumption of plastic has been in the packaging industry. With increase in online shopping, packaging requirements for online marts has resulted in increased solid waste in terms of packing materials. Earlier practice of ink pens or refill replacements has been replaced with the use and throws plastic pens. The similar practice is there for other items like the safety razors, pet bottles for water

soft drinks etc. To support the increased demand, the plastic production has grown at a rate of 10 % every year in the last ten years[20]. The increase in number of nuclear families and one to two children per household have also given rise to discarding of items in place of reuse in terms of children's books, toys, cycles and even clothes. All these discarded items result in increasing the overall MSW.

With the economical progress of the country, higher purchasing power, a large middle class population with high aspirations has resulted in increasing acquisitions and procurement by the average Indian households. The Financial Express reported in Aug 2023 that there would be an increase of 65% in the online consumers in six months time period. With population of 140 crores and increased purchasing power, the MSW has also increased. Further, there is a gradual shift from repairing to replacing of unserviceable items, electronic gadgets, machinery, cycles and vehicles. While some of these are recycled and reused, remaining of it adds add to the MSW. (Bhattacharya, et al. 2018), state that there is a generation of 15,342 Tonnes of plastic waste everyday in India.

2.3 Municipal Solid Waste Management (MSWM): Existing Practices in India

MSWM is a relatively new field in India that has gained importance primarily after launch of the SBM 1.0 and SBM 2.0. It took 73 years after independence for the Government to publish the first addition of manual for MSWM in the year 2000. In absence of written guidelines, MSWM was being undertaken in unplanned manner and depended on the efforts of civic bodies to keep the cities and surroundings clean. Therefore, while some of the areas remained relatively clean, secondary bins overflowed in most of the cities and waste was being dumped at various landfill sites outside the city.

Kumar, Gaekwad et al. 2004, remarked that most of the Solid waste in India is disposed by land filling in low lying areas located outside, in and around the city centres. Almost 70% to 90% of landfills in India are open dumpsites (Jha, Sharma et al. 2008). Indian cities like Delhi, Bangalore, Chennai, Kolkata and Mumbai have landfills that have massed waste for two to three decades and dumped waste has reached heights of up

to 300 feet in Bhalswa, Delhi to 78 feet in Kolkata (S Goswami & S Baswak, 2021). Landfills remain unpleasant sites and cause not only stench and pollution but also damage the city's aesthetics (Lata, K et al. 2022). The untreated leachate pollutes the soil and underground water and results in health issue in the residents.

2.4 MSWM in Indore City

Most important facet of MSWM remains the segregation of the waste into different types so as to ensure their proper processing and disposal. However in India the most crucial aspects of MSWM i.e. segregation was not adhered to in most of the cities including Indore. The MSW of Indore city grew from 750 MTPD (2011) to 900 MTPD (2017) and 1174 MTPD in 2023. The city generates around 1200 MTPD of MSW (Rashmeet Singh 2021). As per an estimate, the city would be generating 2000 MTPD from current 1200 in next ten years[21]

It was after launch of the SBM 1.0 and SBM 2.0 and the sarvekshan results of 2014 and 2015 that the city of Indore underwent a transformation from 149th in 2015 to 25th in 2016 to being declared the cleanest city of India in the year 2017. (Samuel, M. et al. 2024). The waste scenario of Indore before 2015 was like any other city in terms of waste management. City had a number of garbage vulnerable points that were used in place of secondary bins for dumping of the waste. The garbage used to be littered in and around the secondary bins where ever positioned and attracted stray animals, birds and rodents (Lata K. et al. 2022). The un-segregated garbage was carried and dumped at the Devguradia trenching site where the waste kept getting collected and piled up. In November 2013, report of MP PCB (Pollution Control board) stated that the burning of waste at Devguradia was causing pollution in the area and that only 250 MTPD out of total collected 875 MTPD was being processed at the Devguradia trenching site (DNA 2013).

Expert Committee, CPHEEO, Ministry of Housing and Urban Affairs, (2000), Manual on Municipal Solid Waste Management (First Edition)

The first edition of the Manual on MSWM was published in 2000. Till that time there were no guidelines on the MSWM aspects of governance. The manual on MSWM prepared by the expert committee of the Ministry of Urban Development has in great details brought out all the issues related to the MSWM in India. The manual covers the classification of MSW as household, domestic, industrial, Biomedical etc with each type of waste being managed separately in different chapters. The manual brings out methods for collection, segregation, storage, management, recycling and disposal. It also goes in detail about composition and quality of solid waste, relationship between Gross national Product (GNP) and MSW generation, its rate of increase and seasonal variation etc.

The manual ahs separate chapters for energy recovery from MSW, emerging processing technologies, management of landfills, participation by communities and capacity building. It also covers various legal aspects associated along with policy guidelines. It provides detailed MSW management plans for use by various civic bodies. The information provided has been essential to understand the MSWM in cities and understanding of legal and policy framework of MSWM. The explanation of various terms and definitions along with the flowcharts, diagrams and supporting documents provide a deep insight into the MSWM.

Kushwaha, T. Loya, A. and Jain, P. (2020) , Sustainable Municipal Solid Waste (MSW) Management in Cleanest City of India: A Case Study of Indore Municipal Corporation. *Rethinking Strategies For leadership &Governance in Emerging Gobal Scenari, Vol 11(4), pp 92-102.*

Lack of proper and scientific waste disposal methods was leading to pollution, health issues, and littering of various locations in the Indore city prior to 2015. The study brought out that MSW of Indore has increased from 617 MT/day in 2001 to 1115 MT/day in 2017 with the city population being more than 2.7 Million in 2017 and a

population density of 10,000 people/ sq km. The city is divided into 85 wards and 19 zones. The authors brought out as to how the IMC addressed issue of MSW post launch of the SBM (U) scheme by incorporating technology as well Jan Bhagidari. Grass root level interventions were critical by addressing issues related with the safaimitras, existing methods being incorporated, combination of mechanical and manual sweeping, close monitoring of the deployed personnel and vehicles, odd hour cleaning, water sprays to combat dust, segregation of waste, removal of secondary bins from city, door to door collection, fixing charges of waste collection as per the zones, recycling of waste towards generation of power as well as bio fuel are some of the innovative methods highlighted in the study. Use of specialist vehicles for garbage collection brought down the per tonne waste collection cost from Rs 2886 to Rs 1662. The paper brings out that the results are actually seen on the ground and most important aspects is that of Jan Bhagidari. The paper also highlights leadership of the Mayor and Municipal Commissioner as being the main factor that spearheaded the entire process of change.

Lata, K. Anjita, R. Nair. And Bhatt, S. (2022), Transforming the Urban Waste Mountains: Lessons from Indore's Bioremediation of Legacy Waste. *Nagarlok, Quarterly journal of Urban Affairs*, Vol LIV (Issue 1), PP 1-17

Management of solid waste poses a challenge for the civic bodies. The paper brings out compounding problem of solid waste generation and management. It is estimated that waste generation in the world would increase from 2.01 Billion tomes in 2016 to 3.40 Tonnes in 2050 (World Bank Report 2018). In India the waste generation is predicted to increase from 62 Million in 2014 to 165 Million by 2030. The paper highlights challenges of urban waste in India and brings out planning, co-ordination and execution involved in the bio remediation process. The authors highlight that while land is scarce and expensive, land filling is a common method of disposal of urban waste. (Kumar, Gaekwad et al. 2004) and almost 70-90 percent of landfills in India are open dumpsites (Jha, Sharma, et al. 2008). It is brought out that waste management in India involves people from lowest rung of the society and the job is often passed down in the generations. The World Bank report 2018 reveals that 77% of waste generated in India is

disposed in dumpsites, 18% is composted and only 5% is recycled. There has been positive improvement as shown by the Swachh surveys conducted in 2017 and 2021 wherein in 2017 out of 500 surveyed cities, 297 cities undertook door to door collection and 85 % of cities undertook segregation of waste at all levels. In 2021 survey, out of 4320 cities surveyed, 1161 Municipal Corporations had enhanced their waste collection, 1493 had started waste segregation and 762 had started processing waste on site. The paper gives reference of NITI Ayog 2021 titled waste wise cities, which highlights the environment friendly and financially sustained practices adopted by the Municipal Corporations/ Municipal Councils. The paper also highlights the use of non recyclable plastic in construction of 20 kms of road.

The paper brings out improvement in management practices by biometric attendance of employees, RFID & geo tagging of vehicles and 100% door to door collection of segregated waste. The paper advocates Bioremediation process in using micro organisms in decomposing contamination and argues that the civic bodies need to undertake long terms solutions rather than adopting a band aid approach. The paper covers in detail the MSWM adopted by Indore city starting from the 2015 to 2022 wherein from a city with 1380 secondary bins, 408 dumpsites and 4753 back lanes, the city was transformed to a bin free city by year 2017. The paper lists out the processes undertaken in Indore towards Bio remediation which include the following:-

- Identification of the Devguradia site for Bioremediation.
- Conduct of surveys to map the contours of the site and the quantity of waste.
- Bio-mining or excavation process to make windrows.
- Addition of bio cultures which created bio heat thereby accelerating the decomposing process. This reduced the volume by 40 % and released entrapped Methane.

- Installation of machinery for removal and segregation of waste.

- Removal of inert and plastic waste.

- Addition of Soil and Construction of Green Belt.

In the end the paper brings out that IMCs efforts resulted in transformation of Indore into a landfill free city by clearing legacy waste from landfills, reclaiming valuable land and transformation of the land into a green belt.

Singh R (2021) Municipal solid waste management in the City of Indore- A case study. J Civil Eng Environ Sci 7(1): 008-017. DOI: https://dx.doi.org/10.17352/2455-488X.0000

Cities having population of more than 100,000 generate 67000 tonnes of solid waste per day it amounts to 44% of the total waste generated in country (Jul 18, 2019, answer given in Lok Sabha). The city of Indore is likely to generate 2000 MT of waste every day in next 10 years from the current 1200 MT per day. The study argues that there is a requirement for diminishing the waste to 1500 MTPD by reducing plastic waste and usable food wastage. The study further goes in details of the methods and processes undertaken for MSWM by IMC from collection to transportation to processing and conversion/ disposal. When converting waste to fuel on a daily basis, 20 T of waste gets converted into 700 to 800 kg of CNG which is then used as fuel in the city buses. The paper thereafter dwells into various processes involved in the disposal of solid waste including gasification, incineration, composting, recycling and landfill. The paper brings out that out of the total waste 40 % is that of food and garden waste, 27 % is paper waste, 15% is inert 5% each of glass and textile, 4% plastic and 3 % metal. The most important process which is prelude to the MSWM is that of segregation. The paper further argues that Indore has made a capital venture of 180 crores into the programme and spent 155 crores on its activities in 2017-18. While most of the Municipal Corporations are not able to generate this kind of finances, Indore has successfully generated funds through robust

fee collection and fine structure as well as generating revenue from sale of fertilizers and dry waste. The IMC also generates revenue from collection of fee from each household and commercial venture for the facility of door to door collection. Fee is between Rs 60 and Rs 150 per month depending upon the type of waste generated. The program generated 27 crores in user expenses and remainder of funding is subsidized by property tax.

Vasudevan, R. Faisal Zia, S. Sanjeev, A. and Mohammad,E Khan. (2016), Solid and Liquid Waste managemen, Waste to Wealth, PHI Learning Pvt Ltd, New Delhi.

Vasudevan, R. et al argue that in USA about 75 % of solid waste goes to the landfills and approximately 90% of the water is recycled. Whereas, in India 29 % of collected solid waste is treated and the rest of the solid waste is either recycled or composted and less than 25% goes to landfills. Further only 30 % of the waste water is treated and remaining remains untreated and pollutes the rivers or water bodies. MSW in India was around 0.1 Million MT per day in 2002. This increased to 0.573 MMT per day in 2008. The authors bring out that the collection efficiency of MSW varies between 22% to 60% with the composition of MSW being Biodegradables (51 %), Recyclables (17 %), hazardous components (11%) and Inert (21 %). Further 40% to 80 % of MSW remains uncollected that either gets littered in streets or enters the drains and sewerage system of the city. Consumption of plastic in India was 8 million ton /day in 2008 out of which 6 MTPD was being converted into waste. Around 70 % of plastic is discarded as waste in India and about 60 % of the discarded plastic is recycled while remaining 40 % remains uncollected. Therefore, the collection and segregation process is an important function of MSWM. Without proper segregation and collection, it would be difficult to manage MSW. The author's bring out various technologies for MSWM and depict diagrammatic representation for waste to energy flowchart. The authors argue that there is potential of developing approx 1500 MW of power from MSW in India. Amongst the states, Maharashtra has the highest projected capability of 250 MW closely followed by Uttar Pradesh being 154 MW production as per 2009 figures.

The book explains various processes for MSWM in detail that include bio-methanation, palletization, aerobic & anaerobic treatment, composting & vermin-composting as well as processing of LFG (land fill gas) for power generation. The book brings out details of various case studies towards MSW management inclusive of cities and towns like Namakkal, Rajkot etc. Namakkal (Tamil Nadu) was the first municipality to privatize MSW management in India right from segregation at source to D2D collection, production of compost, and recycling. With innovative measures like night sweeping, 100% segregation and D2D the town has become a zero waste town in India. Rajkot generates approximately 300 MT of MSW per day. Waste processing plant was commissioned in 2006 and since then the dry waste is turned into RDF for use by cement factories and remaining 20 to 30 % of wet waste is composted. The city generates 40 MT of bio fertilizer, 70 Mt of RDF and 2.5 MT of plastic is recycled. The gas generation plants at Ajitmal Gobar gas research station produces 9000 cubic feet of Methane per day with different mix of manure and vegetable waste.

The authors highlight that privatizing the MSWM by Namakkal town in Tamil Nadu has not only ensured zero waste, it has also resulted in creating energy from waste. Some of these methods have been duplicated in other cities and towns including Indore including night sweeping, source segregation, D2D collection and waste to energy creation.

Karthykeyan, D. Aziz, A. Chatri, A. and Shah, S. (2012), Public Private Partnership in Solid Waste Management: Potential and Strategies, Ganesh & Co, Chennai

The authors bring out that while an average Indian generates approx 0.3 to 0.6 kg of waste per day, an average American generates 2 kg of waste per day and in Hong Kong it is 5.07 kg of waste per person per day. The authors argue that the low waste generation in India in comparison to USA or Hong Kong is due to a major portion of the waste being recycled at the household level itself through the network of Kabadiwallas. The authors highlight that India has a good waste recycling system and the informal sector plays a significant role in it. Further, the waste generated in the Indian cities is also different

from those of the industrialized high Income countries. Studies have shown that there is a direct relationship between a country's income level and quantity of bio degradable waste in the total waste generated. Compared to high income group countries, India has a larger share of bio degradable and inert waste in its MSW.

The composition of waste generated in India has seen a marked change in the last two decades. Authors provide a representation of difference in MSW characteristics of 1996 to that of 2005. Bio-degradables have increased from 42 % to 48 %, inerts have reduced from 45 % to 25 % and plastic has increased from 1 % to 9 %. This is attributed to changing lifestyles, creased income and increased industrial/construction activity. This highlights how the composition of MSW changes due to economic progress of a country.

Chapter 3

Research Methodology

3.1 Study Objectives

Transformation of Indore city into cleanest city of India is an important subject for study and learning MSWM. This study would not only assist in understanding the overall process of MSWM it would also provide valuable insight into the innovative approach and problem solving experience of the IMC. The objectives of this study are:-

(a) To understand challenges of MSWM in Indore city prior to 2014/15.

(b) To study the innovative methods and techniques implemented in Indore for MSWM and waste to energy plants under SBM (U) scheme.

(c) To appreciate overall effect of Jan Bhagidari in implementation of the scheme.

(d) To address the challenges of sustainability of the MSWM in Indore.

3.2 Strategy and Design

The Research Strategy developed to assess MSWM practices in Indore city is a balanced mix of theory (academic) as well as practice (practical aspects) and utilizes both qualitative as well as quantitative approach. A detailed review of literature was undertaken of both government and non government sources utilizing articles, journals, books and reports. In addition to inferences drawn from secondary research, inputs were

gathered from NGOs, PPP practitioners, residents of Indore and the IMC personnel. The two main approaches in MSWM are technology driven and community driven. These are termed as Centralized (Technology driven) and Decentralized (Community Driven)[22]. Both these practices form an important part of understanding this case study. The effectiveness and sustainability of the present efforts would be measured against the projected requirements of the future with increased population and MSW management requirements of an ever expanding city.

3.3 Research Questions. The paper endeavours to answer the following research questions:-

Q1 What are the current practices of solid waste management in Indore City inclusive of Jan Bhagidari?

Q2 What are the challenges faced in the current solid waste management system in Indore City?

Q3 How sustainable are the current solid waste management practices in Indore City?

Q4 What are the important lessons derived from the MSWM of Indore city?

3.4 Scope and Limitations

The research is limited to determining the sustainability of solid waste management of Indore city only. Certain areas outside the municipal limits of the city have not been considered. The data considered for the study is limited to government sources, research papers, journals and interviews of IMC employees and Indore residents. Technical aspects, methods, processes and technologies for MSW management would be considered from available in practice Indian and foreign sources. Further, e-waste,

radiological waste, hospital waste and their management does not form part of the study. Quantity of E waste generated in Indore is minimal and there are no set procedures for processing E Waste. However, E Waste processing/ disposal are important topics and the same may be undertaken in future studies. Population census was done in 2011 and therefore population growth since then is based on the inputs provided by IMC officials and reports. The projected population growth of the city is based on the growth rate of 3.2 % as brought out by IMC officials in their discussions.

Due to busy schedule of Municipal Commissioner and other officials of IMC, data requested for the research was not provided by IMC. Further, no senior official of IMC was available for interview. In absence of requisite data from IMC, the data was gathered from other sources, papers, journals and through discussions with junior level officials and field supervisors.

3.5 Research Gaps

Overall waste generation of Indore in 2014 was reported to be 1100-1200 MTPD with dry waste being 650 MTPD and wet waste being 450-500 MTPD (SWM Expert, IMC). The MSW generated in 2023 is reported to be approx 1150 to 1215 MTPD which means that the total waste generation has not increased since 2014. Further, the per capita waste generation is reported to be 410 gms per person per day in 2014 and 397 gms per person per day in 2023. This indicates that there has been a reduction in the per capita waste generation. There is also a reversal in waste generation between dry and wet waste as reported. Dry waste was reported to be 600 MTPD in 2014 and wet was reported around 450-500 MTPD which has changed to 450 MTPD of dry waste and 600 to 700 MTPD in 2023. The reasons for reduction in overall waste generation, reduction in per capita waste generation and reversal of dry and wet waste generation in the last nine years may be undertaken by a separate study.

3.6 Focussed Group Discussions

Focussed group discussions were undertaken with IMC employees, consultants, supervisors, safaimitras and people of Indore to understand the implementation of policies and plans, innovations, *Jan Bhagidari* as well as challenges faced by the individuals towards execution of the plans.

Chapter 4

Swachh Bharat Mission

Introduction

All Indian cities including metropolitan cities and even the capital of India have been struggling in the past with MSWM. Certain sights that have been common in most of the cities are open dump areas, overflowing dustbins, loitering stray animals and littered vegetable markets. These were the result of inefficient waste collection, negligible waste processing and dumping of unprocessed waste at landfill sites resulting in high pileup of garbage. Since year 2014, a change in perspective has been brought about by the launch of Swachh Bharat Missions that stressed on the importance of cleanliness, sanitation and SWM in cities towns and villages towards nation building. The SBM 1.0 is a campaign against open defecation in rural and urban areas and has resulted in ODF status of many villages, towns and cities. SBM initiatives resulted in increased awareness about cleanliness and sanitation in both rural and urban areas. SBM 2.0 is aimed at zero waste and zero landfills and emphasizes on the requirement SWM and bio remediation of legacy waste and landfill sites. Most impactful aspect of the SBMs has been the participation by the people in the mission or Jan Bhagidari.

Swachh Bharat Mission 1.0 & 2.0

Swachh Bharat Mission has been launched in two phases. SBM 1.0 was launched on 02 Oct 2014 and SBM 2.0 was launched on 01 Oct 2021.The SBM 1.0 had two main components of implementation, first being achieving 100% Open Defecation Free status (ODF) and second is to achieve 100% scientific processing of solid waste in all statutory towns in the country[23] to be achieved by 2019. SBM 2.0 was launched on 01 Oct 21 as the second phase of the Swachh Bharat Mission. SBM 2.0 has the vision of ensuring garbage free cities by 2026. The main components of the mission are sustainable sanitation, sustainable SWM, used water management, IEC and capacity building[24].

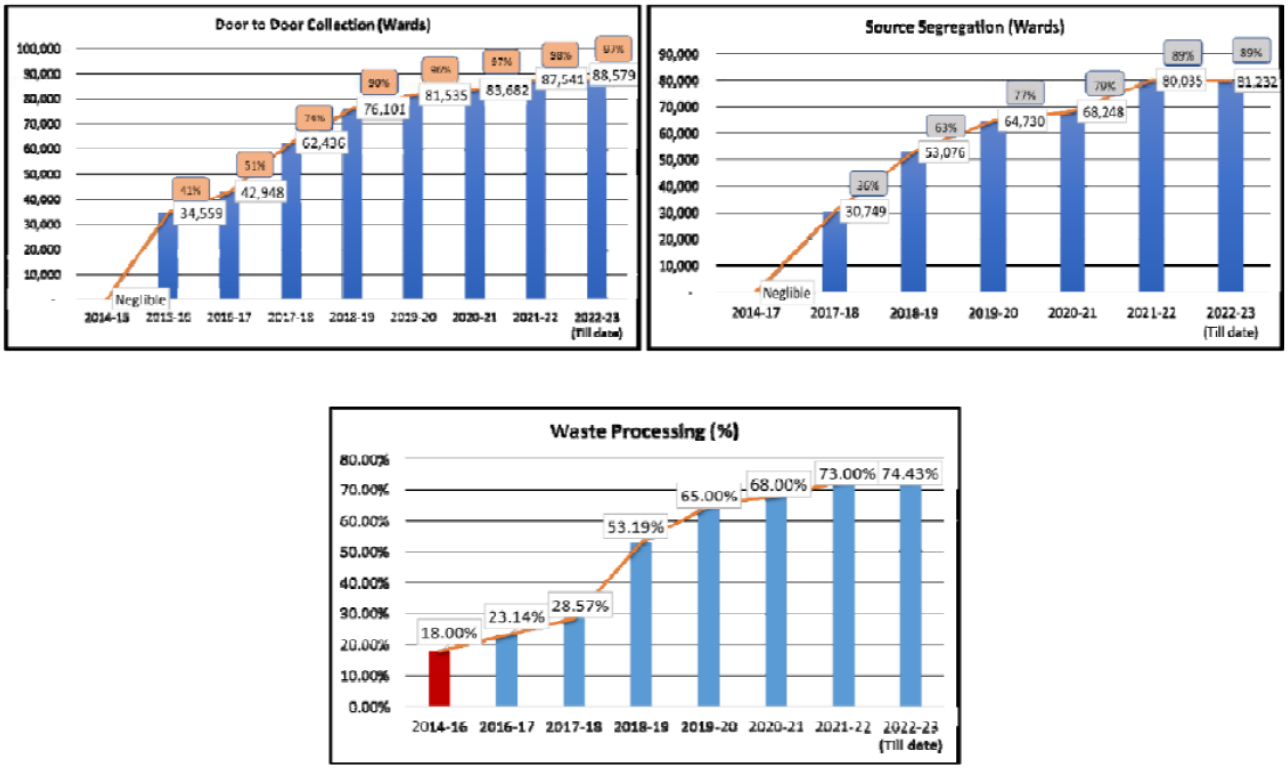
Picture 1: Objectives of SBM

Source: Image: http://swachhbharaturban.gov.in/writereaddata/mission_objective.pdf

4.1 Changes due to SBM (1.0&2.0)

Under SBM 2.0, the focus is on transforming the SWM practices of the civic bodies (municipal corporations/ councils). Funds allocated for SBM 2.0 is Rs 10,884.80 Cr and central government has already released Rs 5803.74 Cr to the states (2022-23) for SWM projects towards waste to energy, bio-methanation, RDF, scientific landfills, C&D management, MRF and remediation of legacy landfills[25]. As per the MoHUA report of 2022-23, 97 % of urban areas are practicing D2D collection, 89 % of waste is segregated at source and 74 % of MSW is processed in India[26]. The progress of these aspects is as shown in figure 3.

Figure 3: D2D collection, source segregation and waste processing in India



Source : MoHUA Report 2022-23

4.2 Wet Waste Processing

India generates approx 1.45 Lakh MTPD of solid waste. Out of this, approx 75,000 MTPD is wet waste and approximately 68 % of wet waste is processed[27]. Wet waste processing capability in India was 18 % in 2014 which increased to 68% in 2021 and has been increasing. As per the MoHUA report of 2022-23, there are 2,285 functional waste to compost plants available and working with a processing capacity of 71,682 MTPD. Additionally, 73 (waste to compost) plants are under construction with total input capacity of 1084 MTPD. An additional capacity of 30,700 MTPD has been proposed. The government has released 29.04 Cr to three states for development of wet waste composting plants[28]. It is further estimated that processing of wet waste for creation of Bio CNG would result in additional generation of 2640 crores per annum if 50% of the generated wet waste is used for conversion to Bio CNG. This would also generate

employment of around one crore man days during construction of plants and around 60 lakh man days towards maintenance and operation.

4.3 Dry Waste Processing: Material recovery Facility (MRF)

The composition of dry waste in India is estimated as 46% plastic, 23% paper and cardboard, 15% textiles, 3% each ceramic, metals & rubber and 9% others[29]. Plastic remains the major component of dry waste. India generates approx 26,000 MTPD of plastic. Out of this 15,600 MTPD of plastic is recycled. MRFs can play significant role in making the dry waste processing circular. If implemented properly the MRFs can help improve recovery from ₹5,187 crores/annum to ₹17,023 crores/annum by 2025 thus adding ₹11,836 crores to economy per annum. As of 2021, there were 2,028 MRFs that were functional with processing capacity of 42,478 TPD. Additional 129 MRFs are under construction with designed capacity of 1,299 TPD. One of the goals of SBM 2.0 is also to set up MRFs with designed capacity of 45,200 TPD so that every city has MRF for processing dry waste. As per the MoHUA 2022-23 report, action plans of 2,096 Municipal Corporations/ Councils of estimated capacity 28,782 TPD have been approved under SBM 2.0[30].

4.4 Waste to Energy

Waste can now be processed to create energy in form of Bio CNG/ electricity/ fuel. There are 99 bio methanation plants (input capacity 2288 TPD) functional in India as of 2022-23 and another 5 plants are under construction (input capacity of 338 TPD). As of 2023, there are 10 waste to energy plants operational with input capacity of 13,900 TPD. Further, additional 10 plants are under construction having capacity of 10,000 TPD.

4.5 Remediation of Legacy Dumpsites

One of the major challenges is the remediation of legacy landfills and dumpsites. With the intervention of courts and state pollution boards, there is renewed focus to make cities

zero landfill cities. It can be achieved only by 100% waste processing and nil dumping. In year 2022, plans were approved for remediation of 13.62 Crore MT of waste for 1,253 dumpsites located in various cities across India. Bio remediation is ongoing at three largest dumpsites at Okhla, Ghazipur and Bhalswa in Delhi for remediation of 2.80 Crore MT which would cost around Rs 1395 Cr.

The swachh sarvekshan and the assessment criteria of cities under SBM (U) have certainly boosted the progress of various municipalities/ corporations towards efficient MSWM. The changes are visible in terms of cleaner cities, increased waste processing, reduced environmental pollution, generating energy from waste and increased employment options. Indore city has performed exceptionally well in the Swachh Sarvekshan which has led to other cities following the Indore model and improving their performance. Gradually all cities are increasing waste processing, undertaking remediation of legacy landfills, constructing scientific landfills and aiming for zero waste & zero landfills.

Chapter 5

Municipal Solid Waste: Processes and Management

As stated in the Manual on MSWM (2000), SWM is the obligatory function of the Municipal Corporations/ Councils and it is falling short of the desired level of efficiency and satisfaction resulting in health problems, sanitation and environmental degradation[31]. Prior to understanding the issues related with the management of MSW it is essential to understand the process of generation, segregation, transportation and disposal of the MSW.

5.1 Principles of MSWM

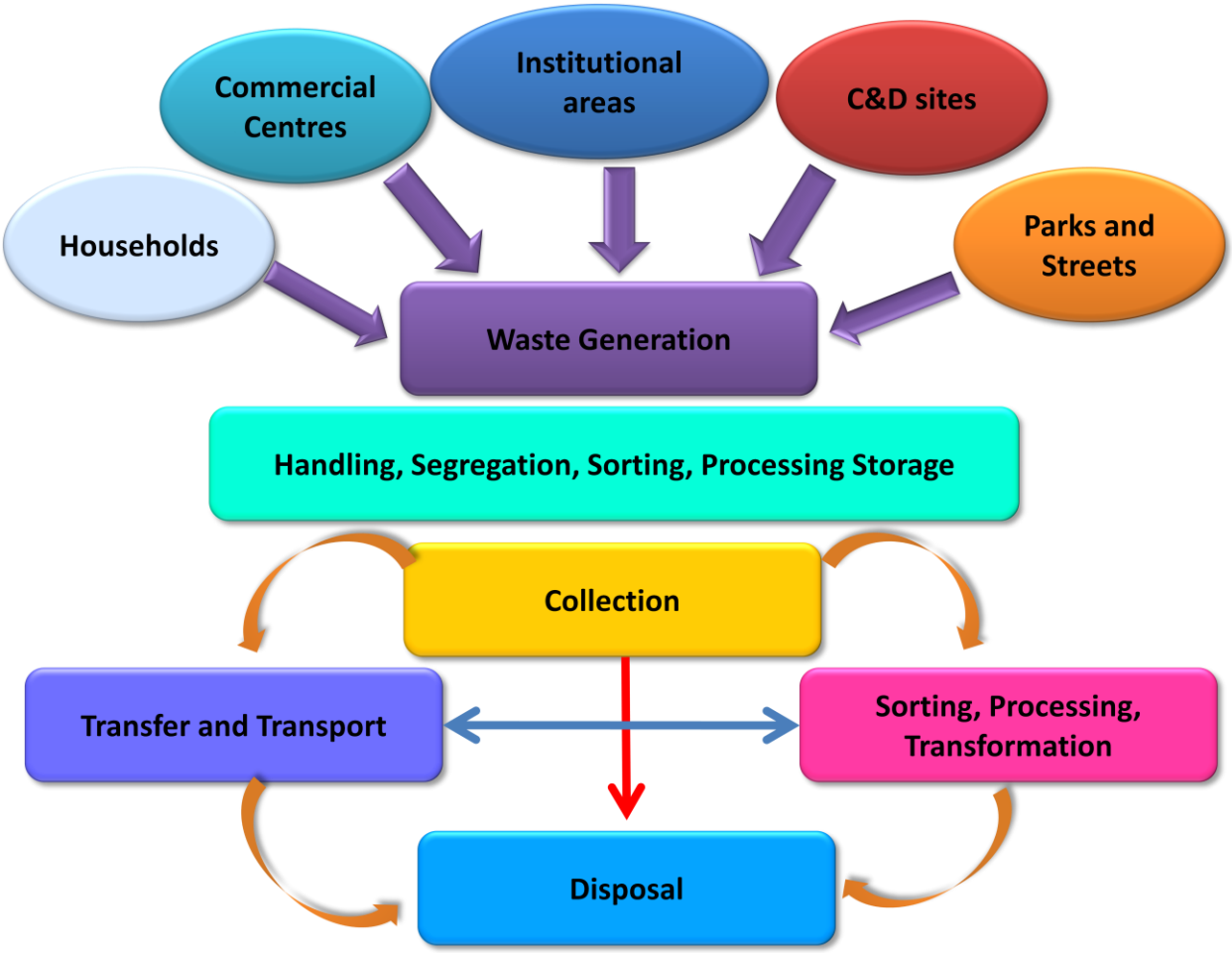
MSWM covers all suitable techniques, technologies and management programs for all types of solid waste from all sources to achieve the waste reduction and management of waste produced after waste reduction. While reduction can be based on the three Rs Reduce, Reuse and Recycle, the Effective management of solid waste should be environmentally as well as economically sustainable[32]. An effective waste management system includes one or more of the following options:-

- Waste collection and transportation
- Resource recovery through sorting and recycling. i.e. recovery of materials through separation.
- Resource recovery through processing. i.e. recovery of materials such as compost or recovery of energy through biological, thermal or other processes.
- Waste transformation (without Recovery of resources) i.e. reduction of volume toxicity or other physical / chemical properties of waste to make it suitable for final disposal.
- Disposal on land i.e. environmentally safe and sustainable disposal in landfills.

5.2 Waste Generation

The functional elements of MSWM are shown at Figure 4. The waste generation centres can be households, commercial centres, institutional areas C&D waste parks and streets. MSWM would institute handling of this waste, segregation into types of waste, sorting out of the part, that can be m can reused/ recycled, transportation and storage of the waste at selected places or transportation to other facilities for disposal either for conversion into energy or for bio composting or for scientific disposal of the inert at designated sites.

Figure 4: The process of MSWM



Source : Flowchart compiled by author based on Manual of MSWM MoHUA (2000)

5.3 3Rs: Reduce- Reuse- Recycle

This is the first step towards management of MSW. This would ensure that the intake itself is reduced thereby ensuring reduced output. Reuse of the items/ equipment would ensure that the same item that may be of limited use to one individual may still be used by others thereby ensuring that the item gets down-graded to MSW only after it has completed its life. Recycling of equipment would ensure that the useful portions of the item are taken out and only the ones that cannot be utilized are declared as waste.

Figure 5: Reduce, Reuse, Recycle

Source : LAHS Eco Engineering

(https://lahsecoengg.wordpress.com/2020/07/07/what-are-the-3-rs-of-solid-waste-management/)

5.4 Steps in MSWM

- **Segregation at Source** Segregation at source is the most important step and also ensures participation by the residents. Segregation into different types ensures that waste is categorized, stored, transported and processed as per type. In case the segregation is not proper, waste would be mixed thereby requiring additional technology, effort and process for its segregation. It would also ensure zero remnant of waste after processing and therefore no dumping at the landfills. However segregation at source can be successful only by the participation of the people or the residents. People need to be responsible and meticulous in segregation of waste. Towards this education, information and motivation of the residents would form an important part of the IEC campaigns.

- **Processing at Source:** Households and other commercial places can process some of the wet waste at source through composting or bio methanation plants. The suitability of a composter or a Bio Methanation plant would depend upon the waste generated per day and the requirement of compost. As per th SBM rules 2016 all bulk waste generators are to process the wet waste at source through Bio composting. Few cities have also installed bio Methanation plants at vegetable markets and also at garbage transfer stations to generate Bio CNG. Bio composting can also be employed by RWAs and other residential societies that would require the compost for maintenance of the gardens and parks located within the society or in its vicinity.

- **Collection and Transportation**. Segregated waste from source is transported into segregated bin vehicles to ensure the purity of type of waste. Towards this it is essential to use specialist vehicles with segregated bins. Specialist vehicles are required to transfer the waste further to the processing plants. The control and monitoring of these vehicles is essential to ensure efficiency in operations and cost.

- **Intermediate Storage**. Intermediate storage places or location are required from where the segregated waste can then be transferred onto larger vehicles for further transportation to processing facilities. The intermediate storage need to have facility for segregated offloading, storage, loading as well as recording data.

- **Processing Facilities**. Different types of waste have different processing facilities employing different scientific techniques to process the waste. While the sanitary and bio medical waste are sent to the incinerators, wet and dry waste are processed for compost/ energy generation. All recyclable items are removed prior to processing.

- **Biological Processes:** This involves using micro-organisms for decomposition of the bio degradable components of waste. This process is of two types Aerobic and

anaerobic. Aerobic process is primarily composting wherein the usable product is compost that can be utilized in organic farming as fertilizer. In the anaerobic process the usable product obtained is Methane gas which can then be stored and utilized for powering vehicles as CNG or used in electricity generation.

- **Thermal process:** This involves conversion of waste into gaseous, liquid and solid products with release of heat. It is of primarily three types; Combustion (Incineration with excess amount of air), Pyrolysis (thermal process with complete absence of air) and Gasification (thermal process with less air). The three types of combustion systems that are used extensively are MASS (Mass fired combustion systems), Refuse Derived Fuel (RDF) fired combustion system, and Fluidized Bed (FB) combustion systems.

- To ensure viability of the solid waste for thermal processing, the solid waste must have a high calorific value. In developed countries the MSW generated has plastic and paper content in it thereby the calorific values generated are to the order of up to 2000 kcal whereas in India in absence of plastic and paper the max calorific value obtained from the MSW is up to 1000 kcal. In this form this waste is not typically suited for thermal processing. However, with combustion systems operating on low calorific values this solid waste is utilized effectively for thermal processing or some additional waste is added to it to increase it calorific value.

5.5 Hierarchy of Waste Management Options

The hierarchy of waste management options starts with the minimization/ reduction of waste at source followed by Recycling, Waste processing (with recovery of resources/ materials and energy), waste transformation (without recovery of resources) and disposal on land (land filling)[33].

Figure 6: Hierarchy of Integrated Solid Waste Management

Source: Compiled by author based on Manual of MSWM (2000) MoHUA

MSWM process begins with the sorting process at source and aids in minimization of the waste. Therefore it is at the top of hierarchy of MSWM. Therefore, Sorting at source means segregation of the waste at the households itself wherein the waste generated at the households can be easily segregated into the following types:-

- Dry Recyclable materials like paper, glass plastics, cans, tins etc. This can be further subdivided into separating plastic waste from the dry waste and separating the glass for recycling.

- Wet waste comprising of kitchen organic waste or garden organic waste

- Hazardous wastes like the used battery cells, thermometers and other chemical agents used in the households.

- Construction and demolition waste

- Sanitary waste

- E waste

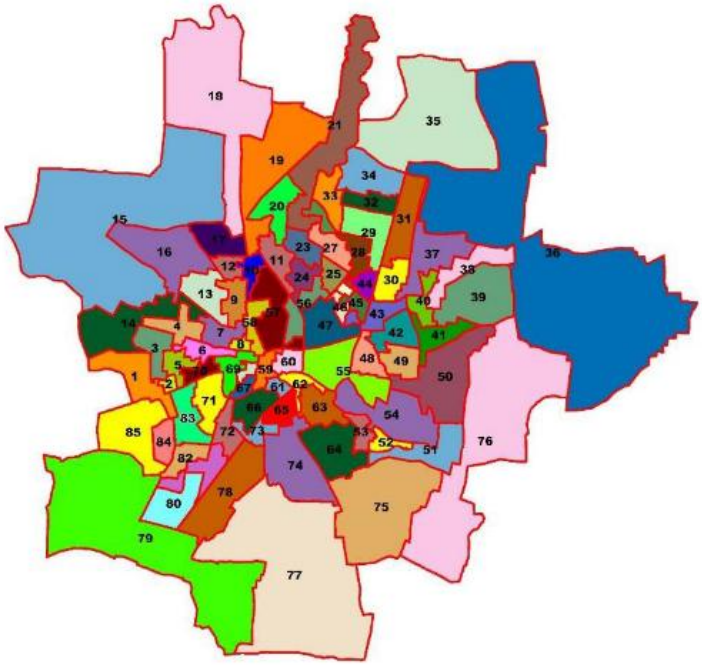
Chapter 6

Indore: City Profile and Challenges

6.1 City Profile

Indore is the business capital of the state of Madhya Pradesh. The city had a total area of 235 sq km with 9335 persons per square km as per the 2011census. With increase in municipal limits, city area as per 2017 data has increased to 275 sq km and approx 10,000 people reside per sq km. Indore has modern infrastructure with agro industries, IT and corporate companies along with educational, engineering and management institutes that attract students from other states of the country. Indore is a busy city with parking and traffic related issues and its businesses comprise of textiles, IT, automobiles and steel industries[34].

Figure 7: Ward distribution in Indore city



Source: Smart City Indore, IMC

Population growth of Indore is displayed in Table 3&4 with data from 2001 and 2011 census. There were 13 urban centres as per 2001 census (including Indore city as one centre) and an urban population of 17,30,363. This increased to 24 urban centres with population increasing to 24,27,709 in the 2011 census. Similarly the population per sq km also increased from 6844 to 6953 along with the increase in area considered from 252 sq km to 349 sq km.

Table 3: Population Census data 2001

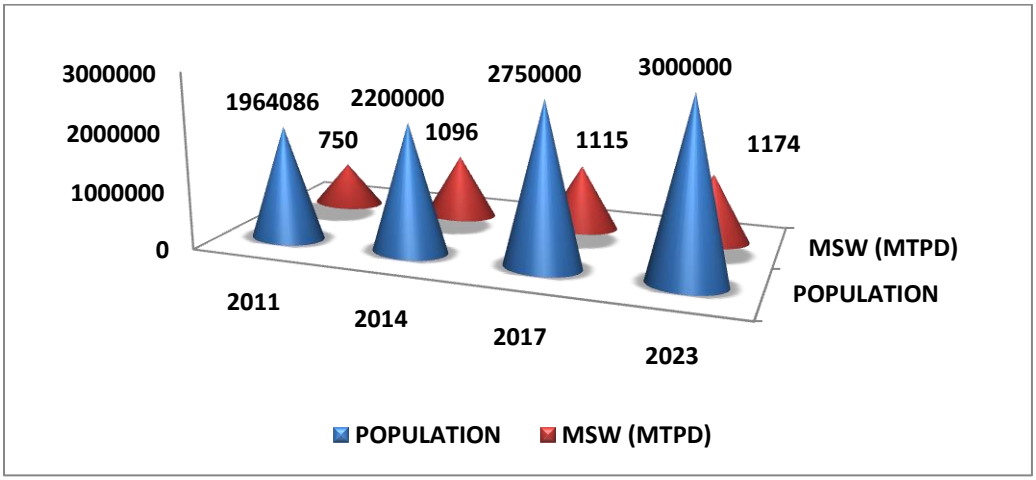
2001 CENSUS							
District/ Sub-district of Indore	Total/ Rural/ Urban	Number of villages inhabited/ uninhabited	No. of towns	No. of house holds	Population	Area (In sq. km)	Population Per sq. km.
Indore	Total	625/15	13	447478	2465827	3898.00	633
	Rural	625/15	---	125637	735464	3645.17	202
	Urban	---	13	321841	1730363	252.83	6844

Table 4: Population Census data 2011

2011 CENSUS							
District/ Sub-district of Indore	Total/ Rural/ Urban	Number of villages Inhabited/ Uninhabited	No. of towns	No. of households	Population	Area (In sq. km)	Population Per sq. km.
DISTRICT	Total	614/ 15	24	649,540	3,276,697	3898.00	841
DISTRICT	Rural	614/15	---	159,400	848,988	3548.86	239
DISTRICT	Urban	0/0	24	490,140	2,427,709	349.14	6,953
SUB-DISTRICT	Total	118/8	12	482,493	2,389,511	890.97	2,682
SUB-DISTRICT	Rural	118/8	---	36,437	195,847	655.97	299
SUB-DISTRICT	Urban	0/0	12	446,056	2,193,664	235.00	9,335

Source: https://censusindia.gov.in/census.website/data/census-tables

Figure 8: Population growth Vs MSW: Indore City



Source: IMC & Indore Town Population Census 2011-2024

(https://www.census2011.co.in/data/town/802273-indore-madhya-pradesh.html)

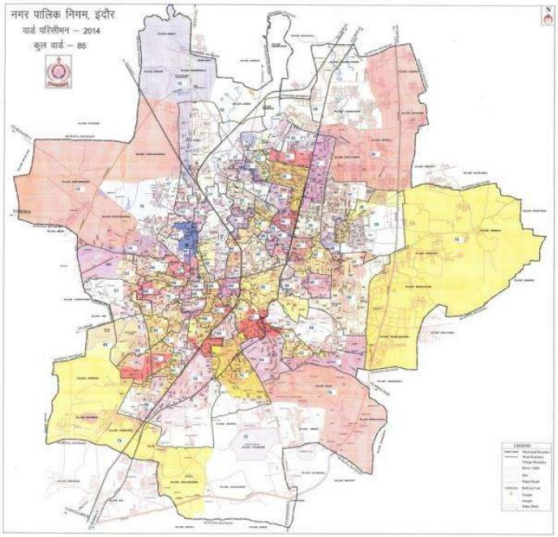
A comparative population growth of Indore city along with increase in MSW generation is given at Picture 2. While the urban population in Indore District has grown from 19.64 lakhs in 2011 to 27.5 L in 2017, the MSW has increased in quantity from 617 MTPD in 2001 to 750 MTPD in 2011 and to 1115 MTPD in 2017. Thus it can be seen that from 2011 to 2017, the waste generation has almost doubled while the population has grown by ten lakhs. With a population of 27.5 L and a waste generation of 1115 MTPD in 2017 the per capita waste generation comes out to be 405 gms per person per day. The increase in waste generation is attributed to:-

- Increase in population
- Increase in purchasing power
- Changing habits of the population
- Transition from repair to replacement
- Increased household waste generation from packaging and online marts

Waste generation not only increases because of increase in population but also changes in the purchasing power, changes in habits and the shift from repair to replace.

E-markets and e-shopping platforms have also increased the overall dry waste component due to increase in packaging requirements.

Picture 2: Indore city population and MSW generation



Area	275 sq km
Population 2017	27.50 lac
Floating Population	3-5 Lac per day
Population density	10000 P/sqkm
No of Households	
+ commercial	6.20 Lack
% urban poor population	27%
No of wards	85
No of zones	19
MSW quantity(2001)	617MT/day
MSW quantity(2011)	750MT/day
MSW quantity(2017)	1115MT/day

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

6.2 Indore City: Challenges of MSWM

MSWM is a municipal function that was not managed both at the city governments' end and at the citizen's end[35]. In absence of any systematic waste collection and disposal process the system relied on piecemeal or stop gap arrangements for undertaking the SWM. The collection of waste was undertaken by corporation workers as well as by the private personnel employed by residents. However, the waste collected from households was dumped at the secondary garbage bins. Responsibility of taking waste from secondary bins to the trenching ground was the responsibility of a private firm. Due to poor management, the waste was littered outside the secondary bins, got dumped at open dumping sites or garbage vulnerable areas. Additionally, the condition of the secondary bins was very poor. There was lack of discipline in the IMC personnel as well as the private firm employees thereby leading to personnel absenting themselves from duty.

Picture 3: Status of secondary garbage bins prior to 2016 at Indore

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

The city had 1380 secondary waste bins that were located at various places and 480 open dump sites[36]. The plight of the waste bins itself was deplorable and has been admitted in the reports of the IMC itself. Further from the secondary bins the waste was picked up and dumped at the Devguradia site. The Devguradia site is located at 12 kms outside the city with landfill site having area of 146.32 acres. However, all the collected waste was unscientifically dumped at this site. Improper disposal and dumping resulted in fires, smoke, pollution, foul smell as well as polluting the soil and underground water.

Due to this, the Madhya Pradesh Pollution Control Board (MPPCB) issued notice to the IMC to take action towards improving the garbage management. In its report submitted to the High Court MPPCB stated that an area of 4 km around the Devguradia site was polluted due to pile up of the garbage and that the burning of the garbage was causing drop in visibility. The MPPCB further stated that around 23000 to 25000 MT of garbage is dumped at the trenching ground every month of which only 4500 MT of garbage is being processed. There was approx 35 Lakh MT of garbage dumped at the site. The MPPCB further noted that there was no segregation system for collection of organic and inorganic waste[37].

Picture 4: Intervention by MP High court

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

The main Challenges for the city towards Management of Solid waste in Indore were:-

- No Segregation of Waste and no door to door collection
- The collected waste being dumped at open sites and in and around the secondary bins
- The waste was then transported and dumped to the Devguradia Trenching ground and dumped unscientifically
- De-motivated Staff (lack of discipline)
- Negligible public participation (No Jan Bhagidari)
- Lack of trust for Indore Municipal Corporation
- Insufficient infrastructure and machinery (limited vehicles for collection)

Challenge faced by the IMC at the commencement of reforms was how to motivate the staff and educate the citizens towards the cleanliness drive. Without the participation of the Safaikarmis and the citizens (Jan Bhagidari), the drive would not have been successful. IMC faced the challenge of transforming Indore from being a littered

city to a clean city. The challenge not only included building up the infrastructure but a complete modernization of mechanism and machinery that included the residents and bring about behavioural changes. Developing and maintaining an efficient system of collection, transportation and processing of solid waste. This was a major challenge as all aspects needed to be planned and executed simultaneously and required participation by all towards a common goal. The details of vehicles and manpower available with IMC in the year 2015 are given in Table 5.

Table 5: IMC MSWM Data

Zone No.	No. of Workers	Bins	Small Vehicles	Cycle rikshaw	Wheel Barrows	Tipper	Loader	Location of Bins	Transfer Points	Open Dump Points	No. of Back lanes
1	300	71	5	10	72	0	1	22	3	33	44
2	484	75	6	16	73	1	1	27	0	13	4
3	283	82	4	10	70	2	1	37	1	4	6
4	328	69	5	19	48	3	1	24	3	16	1190
5	226	65	5	10	48	1	1	27	0	11	306
6	323	72	4	4	41	1	1	34	2	12	213
7	242	77	4	27	48	2	1	26	1	32	150
8	181	54	4	0	3	0	1	4	2	55	350
9	337	80	4	10	32	0	1	28	0	6	0
10	329	86	5	7	47	0	5	25	7	24	35
11	382	95	5	3	70	0	5	50	7	22	111
12	440	85	5	4	79	0	5	46	0	6	41
13	329	80	5	6	26	0	5	25	3	30	71
14	216	55	4	19	63	0	4	13	2	11	600
15	350	76	8	28	23	0	5	18	1	22	224
16	262	58	5	12	38	4	5	12	2	21	554
17	220	66	4	5	10	4	4	18	0	6	560
18	308	79	7	30	50	5	6	19	0	15	271
19	166	55	4	2	18	0	4	3	2	69	23
Total	5706	1380	93	222	859	23	57	458	36	408	4753

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

The table shows that there were a total of 93 small vehicles and only 43 tipper vehicles for the entire collection with 5706 personnel. The area to be covered included 19 zones and 85 wards, with each zone having 4 to 5 wards. There were insufficient vehicles and the workshop of IMC was non functional.

Picture 5: Non functional workshop of IMC

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

The other challenge was of provision of funds for incorporating changes. Since the initial cost requirement towards procurement of new vehicles, modifying vehicles for waste collection, funds for advertisements, IEC campaign and motivation of perople etc needed to be managed.

Chapter 7

Planning and Execution of MSWM at Indore: Graduated Steps to Success

For the management of MSW, zone wise distribution of the city was utilized. Indore city is divided into 85 wards and 19 zones. Each zone has around 4 to 5 wards within it. Each ward has around 6000 families and 600 (approx) business foundations[38]. The new management of MSW was launched as a pilot project in two wards which was then implemented throughout the city. The plan was the brainchild of Shri Manish Singh, then Municipal Commissioner of IMC working in close co-ordination with Smt Malini Gaur then mayor of Indore. The success of the MSWM in two wards was taken as a bench mark towards implementation in the entire city[39]. Successors of Shri Manish Singh were Shri Ashish Singh and Smt Prabha Lata who further expanded the plan and introduced new methods, processes and commissioned processing plants. These measures included bio remediation of legacy waste and incorporating Integrated SWM. The Mayor of Indore Smt Malini Gaur played a crucial role in support of the Municipal Commissioner and was keenly involved in the swachh Indore campaign.

7.1 Solid Waste Management Initiatives.

A broad plan was prepared for MSWM at Indore and the following steps were planned to be achieved:-

- D2D waste collection and segregation
- Evening cleaning and waste collection from commercial areas
- Biometric attendance and GPS monitoring of vehicles
- Waste collection from bulk generators by a separate system
- Litter picking along roads and open area/plots
- Collection, transporting of C&D Waste
- Establishment of Modern Transfer Station

- Scientific waste processing
- Engineered landfill
- Establishment and operation of small composting units
- Establishment and operation of organic waste converter composting system
- Plastic waste collection and processing unit
- Extensive IEC activities through NGOs and PR agencies
- Other allied activities related to SBM such as cleaning of drains, roads, footpaths, mechanized sweeping, creation of green belts etc.

7.2 Pilot Project

Towards achieving the overall plan a pilot project of incorporating the plan in two wards of 42 and 71 was started from Dec 2015 to Jan 2016[40]. This was also undertaken to display its feasibility so as to apply it to the entire city if the model was deemed to be a success. The most important aspect was door to door collection of the waste. Towards this, 80 safaimitra with cycle rickshaws were employed. The aim was to collect the garbage from the source at fixed timings so as to ensure that the garbage does not get dumped at the secondary bins. The waste picked up from households and commercial ventures was segregated in two bins on the cycle rickshaws. Widespread IEC campaigns were also launched in the two wards as well as other parts of the city. The result of D2D collection finally led to the removal of the secondary bins from across the two wards. After the success of D2D collection from wards 42 and 71, the project was expanded initially to ten wards. Once the project was a success in these ten wards, secondary bins were removed from across the city and the project was expanded to include all 19 zones and 85 wards. The journey from initiation of D2D collection from two wards to a bin free city is depicted with timelines in Figure 9.

Figure 9: From pilot project to bin free city

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

With D2D collection there was no garbage that was littered onto the roads or in the open dumps as all was being collected from the source. The waste was initially segregated into wet waste and dry waste. Bin free city campaign started from Mar 2016 to Dec 2016. The earlier system of bringing of waste from homes to secondary bins by "Jagirdars" was replaced by IMC personnel going D2D to collect the waste at specified timings in each locality. Critical bin locations were identified where dumping of garbage was observed to be higher than normal and collection vehicles and personnel were routed to these locations up to three times in a day to ensure that no garbage was dumped.

7.3 Jan Bhagidari

Campaign launched for collection of garbage from doorstep was also ensured by making people aware of the process and benefits. While the D2D collection was the main focus area, the supervisors or the CSI (Chief Sanitary Inspectors) employed in each zone also became the source of taking the complaints and issues of the residents to the IMC. Directed by the Municipal commissioner, IMC worked overtime to ensure that the complaints of each locality were addressed in minimum time. The timely action towards addressing complaints and problems of water supply, drain blockage, road condition, public toilets etc built up trust between the residents and the IMC.

7.4 Deployment of NGOs

Personnel from local NGOs were deployed in sensitive dump areas to educate and inform people of not throwing garbage in the open and to ensure success of the D2D campaign both in the households and the commercial areas.

7.5 Spot Fines and Penalties

Spot fines were levied on personnel caught violating the laid down rules and found littering the area. Shopkeepers were also fined in the marked places for dirty surroundings, garbage littering, use of polythene bags and non adherence to the rules of the IMC.

7.6 Lessons Learnt from the Pilot Project

- With efficient D2D collection, there was no requirement of secondary bins in the wards. Removal of secondary bins from vantage points also ensured no dumping of waste at sites. Monitoring of critical areas and regular cleaning of dumping sites along with penalties to offenders checked and prevented dumping.

- Regular and timely door to door collection instilled confidence in the residents of various localities. Residents observing success in two wards approached IMC to extend the D2D facility in their respective areas. Timely and regular arrival of the waste collection vehicles instilled confidence in the residents and thereby their participation. Residents waited for the arrival of the vehicles for collection of the waste.

- Open dumps and sites ceased to exist and localities became cleaner, which was again appreciated by the residents.

- Due to the success of the pilot project in two wards, political acceptance was accorded for expansion of the system to other wards.

- Earlier cost of collection was Rs 2886/ MT of garbage as 40 safaiwalas and 80 safaimitras were deployed in each ward for collection. Each tipper vehicle could cover one thousand households in a single trip. It was calculated that with use of 3-4 tippers the cost of garbage collection came down to Rs 1662/ MT. This was a significant saving. The breakdown of the cost effectiveness is given in table 6.

Table 6: Operating cost per Metric Ton (Cycle rickshaws Vs Tipper vehicle)

- Operation cost was Rs. 2886 per metric ton

Door to Door Waste Collection through Rikhshaw/ Tricycle			
No of vehicle	40		
Safai Mitra	92	7,500	6,90,000
Daroga	1	8,000	8,000
CSI	1	5,000	5,000
Diesel	1	7,000	7,000
Maintenance	1	4,000	4,000
Driver	1	7,500	7,500
Tata ace	1		-
Total Cost			7,21,500
			72,150
Per tonne cost			**2,886**

Door to Door Waste Collection through Tata Ace-Tipper			
No of vehicle	5		
Safai Mitra	40	7,500	3,00,000
Daroga	1	8,000	8,000
CSI	1	5,000	5,000
Diesel	1	50,000	50,000
Maintenance	5	3,000	15,000
Driver	5	7,500	37,500
Tata ace	1		-
Total Cost			4,15,500
			41,550
Per ton cost			**1,662**

36

Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

7.7 Implementation of Pilot Project in the City

- **D2D Collection and Removal of Secondary Bins:** Based on the lessons learnt from the pilot project, secondary bins were removed from the entire city in a phased manner by Dec 2016 and D2D collection was enforced. This resulted in gradual transformation of the city from a city with overflowing garbage bins to a cleaner city. D2D collection from commercial areas was undertaken in the evening to prevent overnight storage of garbage inside the shops as shopkeepers

would want clean shops in the morning hours for business. Similarly cleaning in commercial areas was undertaking twice a day.

- **Procurement of Tipper Vehicles for Collection:** In 2017, additional 426 tipper vehicles (3 bin) were procured and utilized for D2D collection. Each ward was provided with 4 to 5 tipper vehicles. Cycle rickshaws were employed in narrow lanes for ensuring 100 % D2D collection. Each vehicle was utilised 2-3 times in a day for collection ensuring that all areas were covered[41]. Chief Sanitary Inspector and his deputy were provided with new vehicles for supervision and co-ordination of D2D collection. All the vehicles were equipped with hand held Motorola sets thereby ensuring reliable communication with the control room.

- **Mechanized Sweeping:** Mechanised sweeping, washing of roads, twice a day sweeping of commercial areas were carried out to ensure cleanliness.

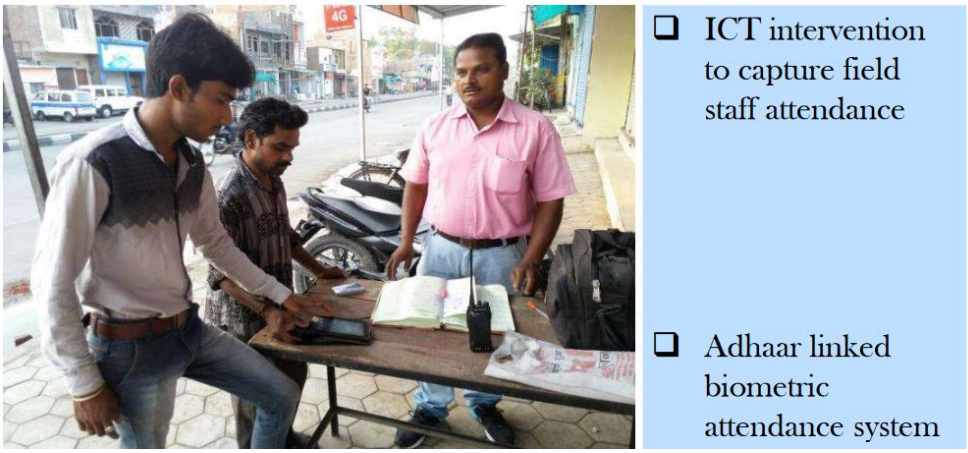
- **Shift Working:** Two separate shifts were followed for day and night sweeping and cleaning which were supervised separately. Attendance of IMC personnel was biometric based and all vehicles were GPS tracked. These measures ensured increased attendance and efficient control of vehicles which was crucial for Integrated MSWM.

- **Bulk waste Generators:** Waste collection was separately undertaken from bulk waste generators like hotels and restaurants by large compactor vehicles. Similarly, separate bio medical waste collection vehicles were used for collection of hospital waste. This collected waste was directly transported to respective processing plants. Waste was being collected @ Rs 3/kg from the bulk waste generators[42]. Bulk waste generators producing more than 50 kg of waste were categorized as bulk trash generators and were to process their wet waste onsite as per the SWM 2016 rules.[43] This reduced the total waste generated that needed to be processed.

- **Home Composting:** On similar lines, households were also encouraged for home composting. Mini compost containers were supplied at subsidized prices to the households with incentive of reduction in the collection fee for households that were undertaking home composting.

- **Management of Sanitary Staff:** 800 new safaimitras were added to have a total of 6200 safaimitras in 2017. Attendance improved after use of Aadhar based biometric attendance system. Around 650 temporary and 90 permanent sanitary workers were terminated for indiscipline and not reporting for work thereby enforcing strict discipline. Every zone had one Health officer, one CSI, one Asst CSI along with drivers, safaimitras and NGO supervisors with each vehicle for D2D collection.

Picture 6: Aadhar based biometric attendance for workers



Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

- **6 Bin Tipper Vehicles:** Two partitioned tippers were modified initially to three bin tippers and later to 6 bin tippers. Waste was segregated at source into six different types as dry waste, wet waste, plastic, hazardous, sanitary and E-waste. The segregated waste was being deposited in respective bins of the tipper vehicles and from the tipper vehicles to Garbage Transfer Stations (GTS).

- **Activities at Garbage Transfer Stations:** There are eight modern GTS at Indore (Star Square, Kabitkhedi, F Sector Sanwer Road, Sirpur Dhar Road, Lalbagh,

Crystal IT Park, Rajshahi, Dakkanwalakuan). Each GTS receives waste in the morning from 4 to 5 zones in 90-99 (approx) 6 bin tippers and 10 open tippers. In the evening the GTS receives 20 to 25 six bin tippers and 10 open tippers. Each tipper has a unique RFID which activates weighing bridge to record the weight of garbage brought in to the facility. Thereafter as the tipper moves, it passes through four stations for offloading of plastic, hazardous, E waste and sanitary waste which are collected at separate storage sites within the GTS. The wet and dry waste that remains in the tippers is offloaded at the green and blue separate off-loaders from where it is compacted into the green and blue capsules. Dry capsule (blue) has a capacity of 10 tones and wet capsule (green) has a capacity of 15 tonnes. The daily waste received at each GTS is approx 70-75 tonnes of wet and 60-65 tons of dry. The quantities received per day of other types of waste are minimal as compared to the collection of dry and wet waste. Therefore, plastic, hazardous waste, sanitary and E waste are picked up from the GTS facility by respective processing plants as per the amount collected or on as required basis. Out of 8 GTS facilities, 5 GTS have double units for offloading of tippers thereby can simultaneously handle more vehicles. Remaining three GTS have single units. Each GTS also has pressure washing facility to wash the vehicles before the shift ends thereby ensuring cleanliness of the vehicles. The GTS facility at Star Square has a 2 TPD capacity wet waste bio gas plant which converts wet waste into bio gas. This bio gas generated is then used in the generator for production of electricity for powering the station itself thereby making this GTS a completely green station.

7.8 Processing Plants at Indore

The processing plants are located outside the city adjoining trenching ground site at Devguradia. It consists of the wet waste treatment by Gobardhan Bio CNG Plant, Nepra MRF for dry waste and C&D waste processing plant. Wet waste (Green containers) is sent to the Gobardhan Bio CNG plant and dry waste is sent to the Nepra facility for processing (blue capsule containers). Plastic waste is collected by Nepra from the GTS,

Hazardous waste by Ramky company Pitampur and sanitary waste is picked up by Hoswin incinerators pvt ltd which also handles bio medical waste.

- **Bio Methanation Plants:** Since 100% segregation at source was achieved, Indore Smart City took the initiative of installation of two Bio-CNG plants under PPP model with capacity of 15 TPD and 20 TPD. The cost incurred was Rs 6.5 and 9 crores under the Viability Gap Funding (VGF) of Rs 10 crore. The main objective was waste processing along with generation of clean fuel for public transport. Later, a larger Bio CNG plant with capacity of 550 TPD was installed at Devguradia in association with Ever Enviro under PPP Model. Indore manages to treat approximately 543 TPD segregated wet waste of 95% purity.

- **Gobardhan Plant (Bio CNG), Devguradia:** This is India's largest Bio CNG plant which is located in vicinity of the trenching ground at Devguradia and is on a 15 acre land for a 20 year lease period. The plant has a capacity of 550 MTPD generating up to 17 T Bio CNG per day from source segregated organics or wet waste along with 100 T of compost. The treatment of wet waste also results in reducing up to 1,30,000 T of CO2 emissions per annum.

- **Wet Waste Processing**: The wet waste brought in from the GTS is weighted and received in a deep bunker from which it is transported by a grip crane to the hopper after initial segregation and transported onto a conveyer belt. The waste is then taken to the trommel for separation of larger pieces. From the trommel the rejects move towards the compost line and the remaining waste is sent through a hammer mill to the hydrolysis chamber. Here the waste is stored for two days for the hydrolysis process. The waste thereafter moves to digester which results in the production of Methane gas. Methane is collected and sent to raw gas balloon. This gas is a mixture of Methane, SO2 and CO2. The gas is purified after removal of the impurities of CO2 and SO2 in the Bio Up gradation Units and 95-98 % pure Methane is obtained which is stored for use as Bio CNG. Some of the gas is also transported through pipelines to Avantika gas limited for commercial use in CNG

vehicles. While 50 % of the gas is used in commercial and private vehicles, remaining 50% of the gas is bought by IMC for its own buses at subsidized rates by Rs 5 per litre.

- The processing of wet waste generates three folds benefits.

    - The wet waste is thoroughly processed at the plant.

    - 100 T of compost/ organic manure is generated every day including the slush that can be further used in farms for farming.

    - 16 T of Bio CNG is generated everyday that is used in private and commercial vehicles (by Avantika gas private limited) and also by the CNG vehicles of IMC.

- **Biomethanation Plant at Choitram Mandi**: The Vegetable and fruit market located at Choitram Mandi was a known organic waste generating spot. Approximately 20-25 MTPD of vegetable and fruit waste is generated at this Mandi. IMC established a Bio CNG plant at the site itself. The plant has a capacity of 20 MTPD and overall cost is approx Rs 15 cr. The plant is capable of generating 800 kg of Bio CNG per day which is 95 % pure and is used to operate 15 city buses daily. Additionally the plant generates organic manure and slurry for farming purpose[44]. Another Bio CNG plant has been established with 15 T capacity.

- **NEPRA Material Recovery Facility:** This facility is located at Devguradia site. The facility is responsible for processing of the dry waste sent from the GTS and received directly from bulk waste generators. The facility has a capacity of processing 400 MTPD of dry waste and is processing approximately 200 to 300 MTPD of waste. The waste received from the GTS is weighed and moves through a conveyer belt and the presorting is undertaken to remove oversized objects. The

trommel thereafter classifies the objects into three categories of sizes i.e size < 50 mm, 50 mm to 300 mm and > 300 mm and metallic objects are removed by a magnetic belt. The low density 2D objects (plastic and paper) and high density objects 3D are removed or segregated by means of Ballistic Machine which works on the principle of ejection and rejection. This separates the items for recycling. The remaining items are processed to make RDF, some additional < 50mm waste is added to increase the calorific value of the RDF. This fuel is utilized by cement factories located at Neemuch.

- **Bio Medical Waste Processing:** 5 MTPD of bio medical waste is collected by the Hoswin incinerators pvt ltd and treated at the Sawer road industrial area. Separate collection and treatment of the bio medical waste ensures that the bio medical waste does not get mixed with the other forms of solid waste. Common Biomedical waste treatment facility has the capacity of incinerating 200 MTPD of the Biomedical waste on site.

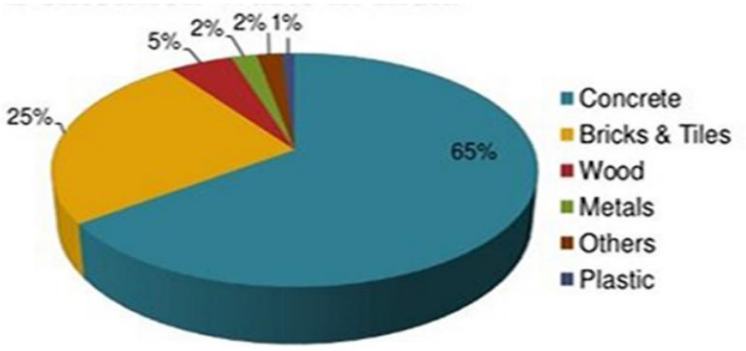
Picture 7: Biomedical waste transportation

Source: Smart City Indore

- **C&D Waste Processing:** C&D waste is inert, non toxic and therefore is low risk for waste management. C&D waste can be considered as a resource for either Reuse after processing or in its original form[45]. The Composition of C&D Waste is as follows:-

    - Cement, concrete, plaster, broken bricks.
    - Steel (RCC, door/window frames, roofing support).
    - Rubble, broken stone (marble, granite, sandstone).
    - Broken timber/wood
    - Soil and sand, gravel, glazed tiles etc.
    - Broken conduits (iron, plastic), broken pipes (GI, iron, plastic).
    - Broken electrical fixtures (copper/aluminum wiring, wooden baton, Bakelite/ plastic switches, wire insulation).
    - Broken panels (wooden, laminated).

Figure 10 : Composition of C&D waste (Source: Ecopro environmental services)



Source: http://ecoproindia.com/construction-and-demolition-waste.html

- The amount of C&D waste in Indore is around 60-70 MTPD which is collected and transported directly to the plant located at Devguradia for processing. The processed waste is then used to prepare interlocking tiles, pillars for fencing, pavement tiles, manhole covers etc. These items are procured by IMC and used for beautification of the city itself. Thereby ensuring that the generated waste is processed and items manufactured are utilized.

Picture 8: C&D waste processing facility, Indore:
Pavement tiles, manhole covers, interlocking tiles etc made from C&D waste are used by IMC

Source: Author's personal collection

7.9 Other Innovative Steps

- **Banning of Polythene and Plastic Bags:** Polythene and plastic bags were banned all across the city. People were encouraged to use cloth bags for shopping and shopkeepers were asked to keep cloth and paper bags for customers. Hefty fines were levied on the shopkeepers who used polythene bags. Unauthorized polythene bags from various places were confiscated and fines levied on individuals as well as firms.

- **Cloth Bag Stitching** Thaila stitching centres under the name of Jholaman were formed where people could get cloth bags made from old and used clothes which would then be used for grocery and other purchases. The initiative of Jholaman was also supported by self help group of women. Outlets were placed in proximity of markets so as to enable the customers to procure the cloth bag from these vantage points. These initiatives of removing the polythene bags completely from the markets, provision of alternative cloth bags at vantage points and penalizing the offenders severely ensured that the use of plastic bags for shopping was totally curtailed.

- **Neki Ki Deewar** Neki ki Deewar was an initiative launched wherein people could put their household items, clothes, books, toys etc which they no longer needed. This could be taken by anyone who needed it and ensured reuse of the items and aided towards reduction in the overall generation of waste. The Neki ki Deewar was located at vantage points where it was accessible to a large number of people.

- **IEC** Dedicated IEC campaigns using popular singers, known personalities, use of FM and TV for advertisements, capacity building for the IMC personnel and safaimitras were employed to enhance awareness level in the residents tthereby making the campaign a success. The efforts of IMC in IEC campaigns resulted in increased Jan Bhagidari.

7.10 Remediation of Landfill at Devguradia Trenching Ground

Picture 9: Devguradia trenching ground image prior to Remediation

Source: Indian Express (8 Dec 2022), A tale of two cities

Devguradia site was functional as a land fill site for last 40 years. Over a period of time, residential areas came up in the vicinity of the site, with closest being only 200 mts away. Unauthorized burning of waste and foul smell from the site led to PILs filed in the Madhya Pradesh High Court. Madhya Pradesh Pollution Control Board (MPPCB) reported that the quality of water in the area was critical and needed immediate attention. MPPCB further directed IMC to undertake processing of solid waste and to find solution to the dumping problem. IMC conducted surveys to identify the areas that would be suitable for Bioremediation process[46]. The site for Bioremediation needs to have correct

geophysical, geochemical and biological characteristics[47]. A survey revealed that the site was suitable for bio remediation. Contouring of the site was undertaken using DGPS to determine the total quantity of the waste required to be biomined. Area was divided into four parts or sub sites. The results of the survey are given at Table 7.

Table 7: Contouring of landfill site at Devguradia

Location	Area (Sq Mtr)	Average height (Mtr)	Quantity
A	84640	4.50 mtr	3,80,925
B	49186	6.40	2,14,790
C	66493	5.10	3,39,114
D	73089	6.36	4,64,846
		Total **Rounded off to**	**14,99,675** **15,00,000**

Source: Lata, K. et al (2022), Lessons from Indore's Bio Remediation of legacy waste, Nagarlok, LIV Issue I

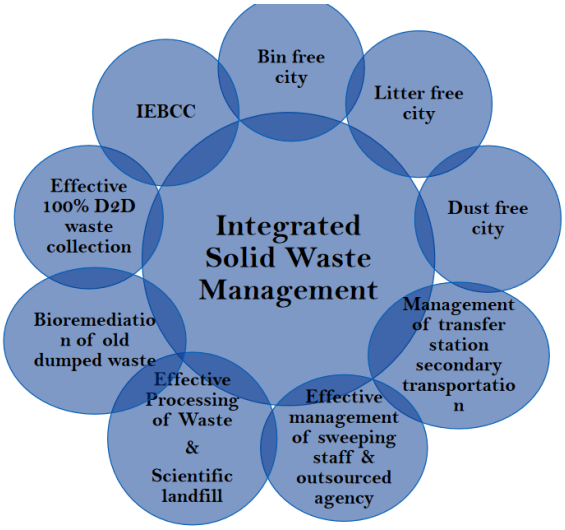
The site was deemed to be fit for bioremediation process. First pilot project for bioremediation commenced in 2016 for approx 50,000 cubic meters of waste by A to Z infrastructure ltd. With the success of the pilot project, tender was floated for the remediation of 100,000 cubic meters of waste. Based on the success of these two pilot projects, Bio Remediation of the entire 15 lakh tonnes of waste at the landfill was undertaken[48]. Since the cost quoted by private contractor was Rs 65 Cr, the Bio Remediation of the landfill was undertaken by the IMC itself. Since specialist machinery for the task was not available with IMC, therefore it was taken on rent. The machinery deployed comprised of trommels (10), Horizontal screens (15) and more than 50 excavators on rent basis. Additionally, 200 plus workers were employed at site consisting of rag-pickers and Kabadiwallas. The daily monitoring was undertaken by a team from IMC. Bio remediation of the entire site was completed in a time period of 6 months. Only 10% inert was remaining that could not be bio mined and was transferred to a scientific landfill located in vicinity. With the bio remediation completed 100 acres of land was reclaimed which was developed into 10 acres as a garden and remaining 90 acres is being developed into a forested area[49].

Picture 10: Transformation of Devguradia landfill site into a park

Source: Author's personal collection

7.11 Integrated Command and Control Centre and Application Based Initiatives

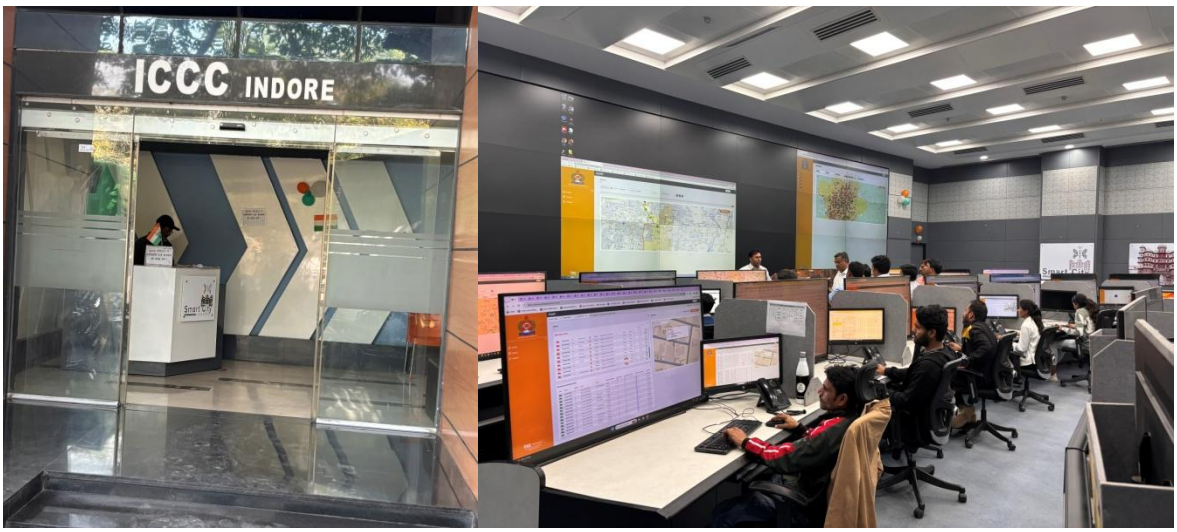
Figure 11: Integrated SWM



Source: https://cdn.cseindia.org/docs/photogallery/slideshows/06_20171212_IMC-SWM-Final-Indore.pdf

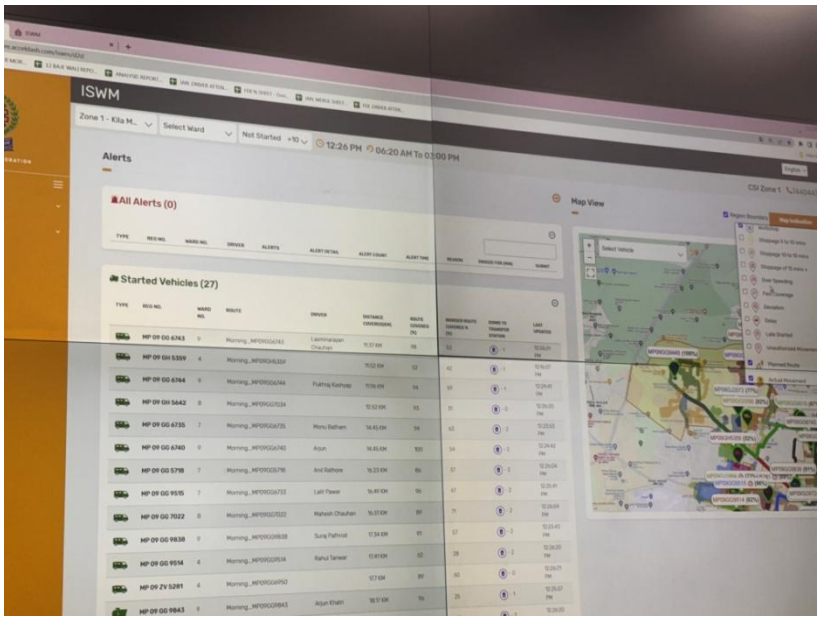
The entire functioning of the door to door waste collection and movement of vehicles is monitored and controlled at the Integrated Command and Control Centre. The ICCC setup comprises of 19 operating stations one for each zone manned by 19 operators continuously. This ICCC setup is to cater for all the 19 zones comprising of 85 wards with each zone having 4 to 5 wards.

Picture 11: ICCC facility at Indore with 19 operator consoles (one for each zone)



Source: Author's personal collection

Picture 12: ICCC System monitoring movement of vehicles



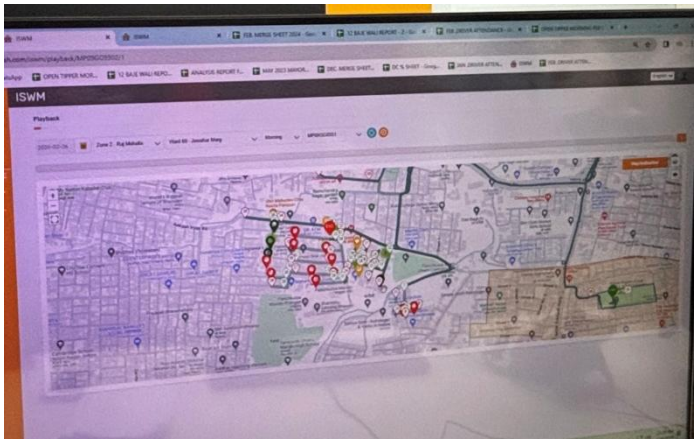
Source: Author's personal collection

The Operations commence at 0530 hrs with the moving out of the vehicles for D2D collection of MSW. Since all vehicles are GPS tagged their movement is monitored on the integrated software at the operator system. The system operates in two shifts for the D2D collection. The system is designed to monitor the D2D collection of waste and monitor the two shift working. Morning shift (0530 to 1500) collects from the households and evening shift (1500 to midnight) collects from the commercial ventures.

The Collection vehicles (Open tippers) are supposed to move out of their parking areas between 0530 to 0600 hours and the 6 Bin tippers depart at 0630 to ensure that the waste collection starts at 0700 from the first earmarked locality. Routes to be followed by are fixed for each vehicle, therefore at every point of time the real time location of the vehicle is known thereby making it easy for the operator to ensure efficient usage of vehicles. Each street and road in each locality have start points (SP) and end points (EP) on the display map. The vehicle in each locality is supposed to move in sequence from SP 1 to EP 1 and thereafter SP 2 to EP 2, SP 3 to EP 3 and so on till all the lanes, streets and households are covered. The crew for D2D collection in terms of vehicles, drivers, safaimitra, NGO supervisor are fixed for each ward and zone. In addition to these, CSI

(Chief Sanitary Inspector) of the zone and his deputy have been provided with a separate vehicle for mobility and supervision. They are able to take timely decisions in case of any contingency that arise on site.

Picture 13: ICCC Start and End points for each street and road



Source: Author's personal collection

Alerts: ICCC monitoring system provides alert to the operator in the following situations:-

- The vehicle does not move from the parking area on time.
- The driver does not report for duty on time.
- The vehicle does not reach the designated start point on time.
- The vehicle stops en-route for more than 10 to 15 mins.
- The vehicle completes the collection before the slated time implying that the vehicle has moved fast or waste has not been collected.
- Sequence is not followed.

Therefore all vehicles need to move exactly as per the designated route, at the designated speed, and designated time. This close monitoring as well as supervision has ensured efficient and optimum utilization of the vehicles as well as gaining of trust of the residents.

The team for D2D collection comprises of one Health officer, one CSI one Asst CSI, and each vehicle having one NGO supervisor, Safaimitra and the driver. The teams for each locality are generally same everyday thereby increasing familiarity and rtrust of the residents. Supervisors responsible for collection from various localities also became the channel of communication between the population residing in these areas and the Municipal Commissioner. Later this role was taken over by the incorporation of 311 application. The D2D collection was charged to each household as per the locality and the size of the houses. On the similar line the D2D collection from commercial ventures was charged as per the size of the venture and garbage generated.

311 App

This mobile application was launched by IMC on 2nd October 2016 as a platform to the residents of Indore for complaint, reporting as well as an information system. The application is based on the 311 non emergency numbers of USA and Canada. It provides one stop solution to provide information about various public services – Traffic, iBus, Helpline, Complaints, information about, Banks, Blood Bank, Bus stand, Community Centre, Colleges, Gym, Hospital, Library, LPG Gas pump, Market, Monuments, Parking places, Petrol pumps, Police Station, Post Offices, Public Toilet, Stadium, Taxi Stand, School, Tourist Places. Thereby the residents are able to launch complaints on the 311 application.

Picture 14: Control room for 311 App

Source: Author's personal collection

Process of reporting on 311 app is very simple. The resident clicks a photo, selects the category of complaint in terms of garbage, road, drain etc, writes a small description about it and submits the same on the application. The follow up is quick and the response is provided by the responsible officials. Towards this, IMC has employed more than 40 operators in the 311 Control Room which is located in the same building housing ICCC to monitor the complaints for fast resolution. The app has been downloaded more than 4.5 Lakh people and has provided resolution of 95 % of the issues highlighted by the citizens.

Chapter 8

Analysis and Findings

The study brought out various aspects of Municipal Solid Waste Management in Indore city. The interviews of officials, NGO personnel, supervisors in the field, safaimitras and the residents of the city provided a deep insight into the unique and innovative approach of the IMC towards transforming the city. The efforts of IMC are evident in terms of sustaining the city into being the cleanest city for seven continuous years. Every year the IMC has built upon the previous year's accomplishment and introduced new theme that has aided efficient management of solid waste. The reports of the Swachh sarvekshan of last seven years bear testimony to the efforts of the IMC towards achieving and sustaining this status.

8.1 Waste Processing

The waste collection for 2014, 2017 and 2023 in Indore are given at table 8.

Table 8 : Waste collection in Indore city

Year	2014	2017	2023
Waste (MTPD)	1096	1115	1174

Source: IMC data

Waste collection in 2014 was 1096 MTPD as reported by the IMC. However, the processing capability of IMC prior to 2016 was only 10% to 30 % of the total collected waste. This led to a large portion of unprocessed waste being transported to the landfill site at Devguradia. The other reasons for dumping of MSW at the landfill site were due to:-

- Lack of processing plants
- Non segregated waste/ mixed waste
- Poor storage and transportation facility
- Very limited processing capability for both dry and wet waste.

Year wise details of the processing capability at Indore are given at Table 9.

Table 9: Year wise MSW processing capability of Indore

Year	Processing capacity
2014-2015	5-10 %
2016	10-30%
2017	60-70%
2023	100%

Source: IMC data

Processing capability improved from 2017 due to the following reasons:-

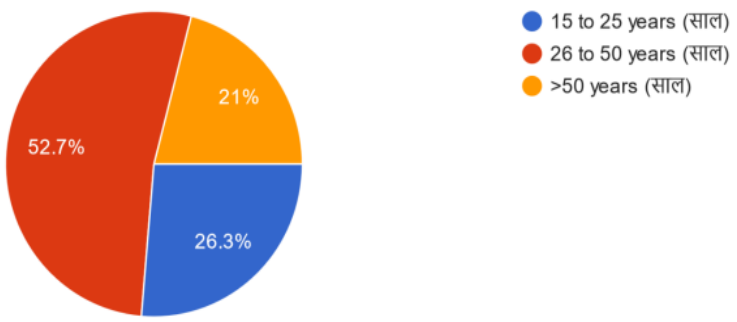
- Segregation of waste.
- D2D collection.
- 6 Bin Tipper vehicle.
- State of art machinery, vehicles and GTS facility.
- Commissioning of Bio CNG plant (wet waste processing) and MRF plant (dry waste processing) and converting waste to energy.
- Promoting household and composting by bulk waste generators.

With these measures, Indore has been able to achieve 100% waste segregation, 100% D2D collection, 100% processing and zero landfills.

8.2 Jan Bhagidari Analysis

Towards assessing the Jan Bhagidari in the efforts of IMC, a questionnaire was prepared for the residents of the city along with focused group discussion to understand the involvement of residents and their efforts towards sustaining the efforts of IMC towards MSWM. The questionnaire for the residents comprised of 11 questions the details of the same are given in figures 12 to figure 23. A total of 315 residents of Indore city replied to the questionnaire.

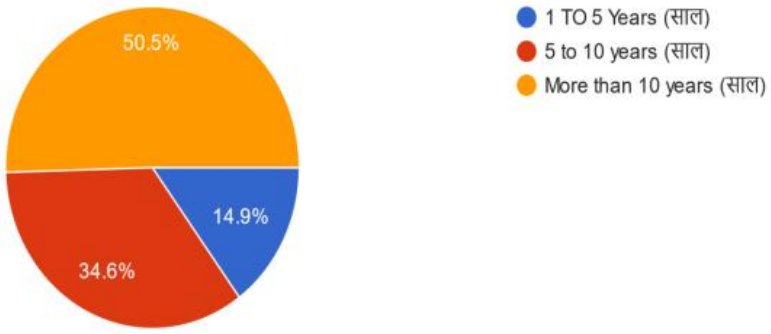
Figure 12: Age bracket of the participants (315 responses)



Source: Response to Question No.1 of the questionnaire

Out of the 315 residents, 166 (52.7%) were in the age group of 26 to 50 years, 83 (26.3%) were in the age group of 15 to 25 years and remaining 66 (21%) were in the age group of more than 50 years. A total of 232 respondents out of 315 were above the age of 26 years and formed the majority of the people who responded to the questionnaire.

Figure 13: Period of stay in Indore (315 responses)



Source: Response to Question No. 2

Out of the 315 responses, 159 residents (50.5%) were residing in the city or more than 10 years, 109 (34.6%) were residing in the city from last 5 to 10 years and 47 (14.9%) resided in the city in last 1-5 years. Thus a total number 268 respondents would have witnessed the changes in the city's MSWM first hand.

Figure 14: Transformation of Indore into a cleaner city in last 5 to 7 years

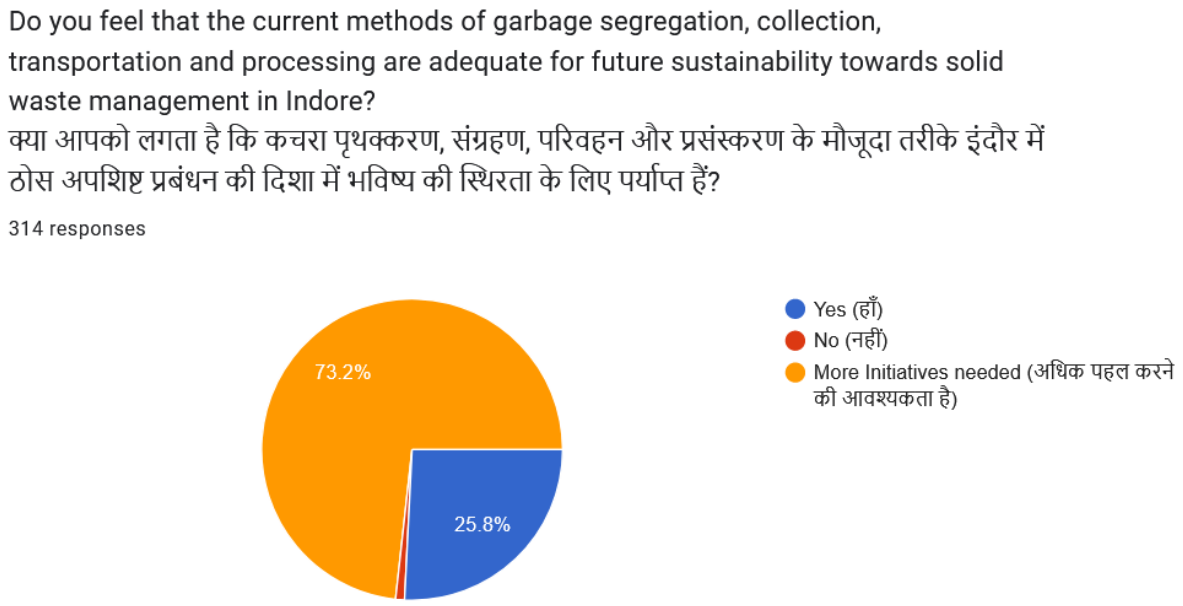
Source: Response to Question No. 3

To the question if Indore city has become cleaner than what it was 5 to 7 years before, almost 100% of the residents replied that the city was much cleaner than before in last 5-7 years and that the D2D collection of garbage was taking place from their doorstep by the IMC.

Figure 15: D2D collection of garbage

Source: Response to Question No. 4

Figure 16: Method of segregation, collection and transportation and its sustainability

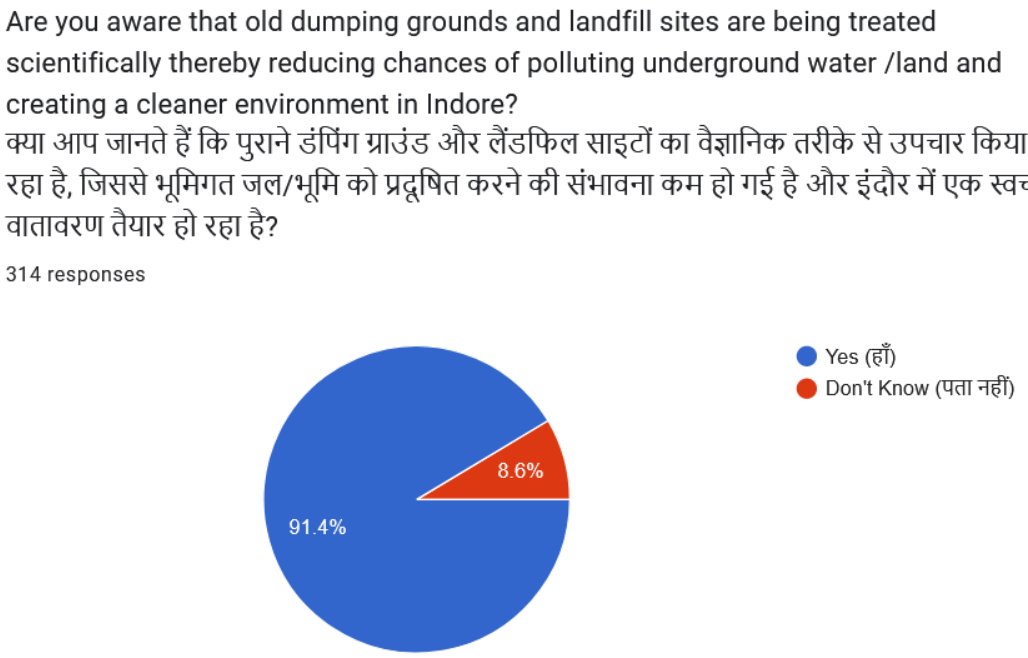


Source: Response to Question No.5

On the query of whether the existing methods of garbage segregation, collection, transportation and processing are adequate for future sustainability 73% residents responded that more initiatives were needed towards making the efforts sustainable for future. This was also highlighted during the personal interviews and discussion with the residents as well as the employees of IMC that new and innovative means need to be undertaken to ensure that the city is able to sustain the cleanliness drive in future with the increasing of population and incorporation of new areas into the city municipal city limits. Municipal limits of Indore would be expanded to 22 zones from existing 19 zones in 2024-25 by including new villages and sub urban areas located on the periphery of the city. MSWM has been introduced in these areas and the people are being educated about segregation of waste and the mechanism of D2D collection so as to have a smooth transition when these areas are included in the municipal limits. This would require additional vehicles, staff, equipment, incorporation of new areas into ICCC, and increased budget. However the most important aspect would be to involve the population residing in these areas and orient and include them in the overall plan. The IMC personnel reported that they have already started the drive of garbage collection from

these areas (that are yet to be fully integrated) as well as IEC campaigns have been started towards increasing awareness of the residents.

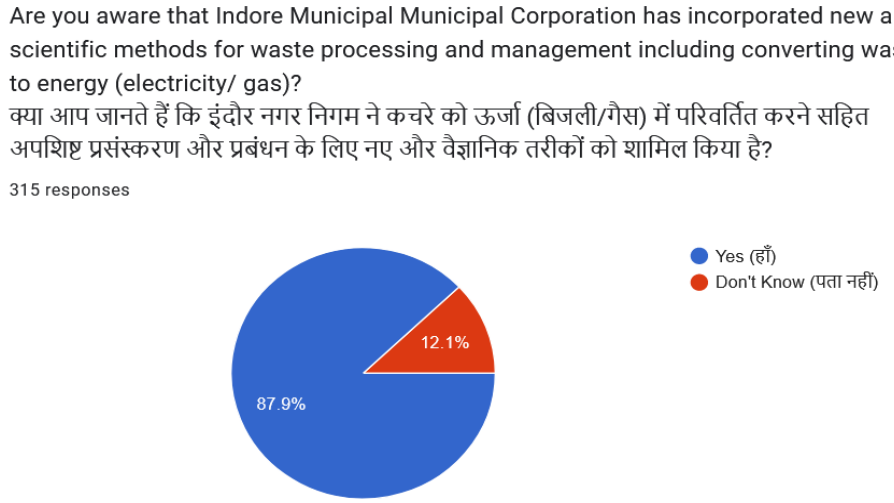
Figure 17: Knowledge of remediation of landfills



Source: Response to Question No. 6

The awareness of the residents about the remediation of landfills was evident from the fact that 91.4% were aware about the remediation of legacy landfill site at Devguradia. The residents during the interviews and discussions also brought out that the place had become much cleaner and there was no foul smell emanating from the site. Some of the people interviewed, resided in near vicinity of the site and could vouch for the transformation of the site completely. Post Bio Remediation, the colonies and residences in vicinity of the old trenching ground reported cleaner air and no pollution from the site. Additionally, the site was transformed into a park and a garden spread over 10 acres of land. The transformation of the landfill site was seen as a major change by the residents and also the efforts of IMC were applauded by all of achieving it in record time of six months. This also led to reclaiming almost 100 acres of land.

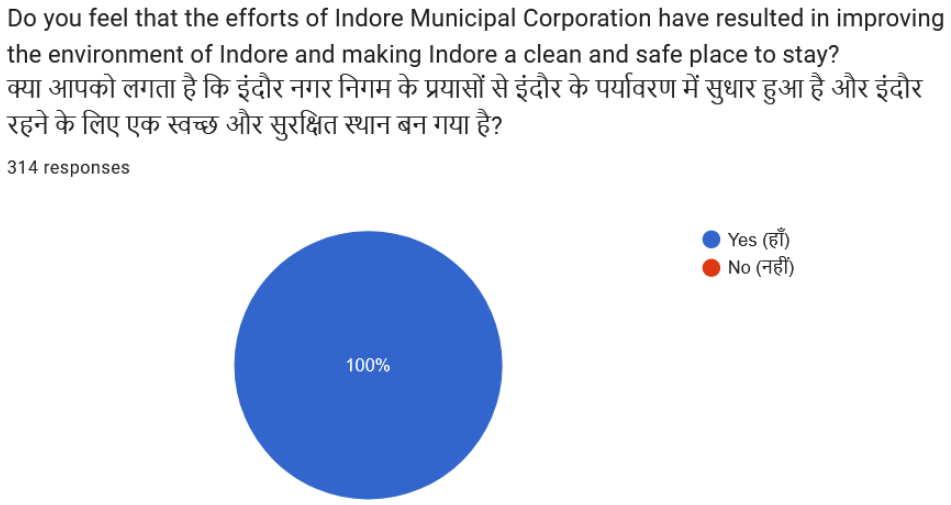
Figure 18: Information about waste processing and waste to energy



Source: Response to Question No. 7

87.9 % of the residents were aware of the waste management processes that were involved which included processing of wet and dry waste and also that energy was being made from the waste which was further ensuring cleanliness of the environment as the gas produced was used by vehicles. The residents were aware of the usage of CNG in the IMC buses thereby ensuring lesser pollution.

Figure 19: Acknowledging efforts of IMC

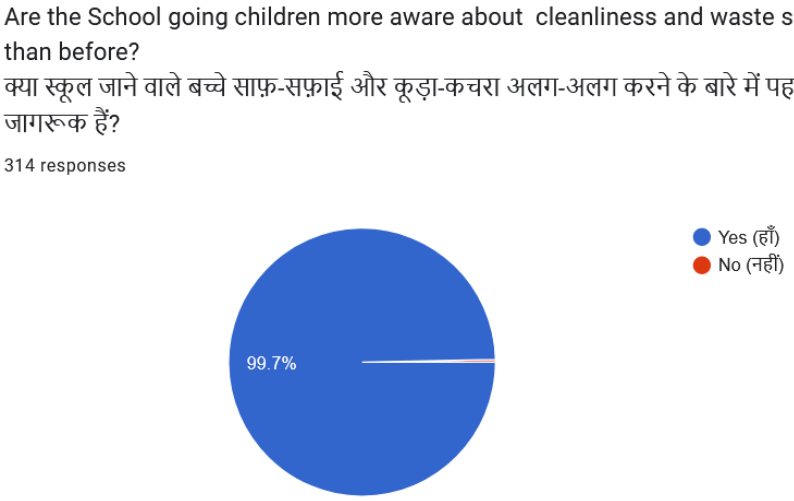


Source: Response to Question No. 8

All residents agreed that the efforts of IMC have resulted in ensuring that Indore is a cleaner and safer pace for living. The awareness about cleanliness and waste

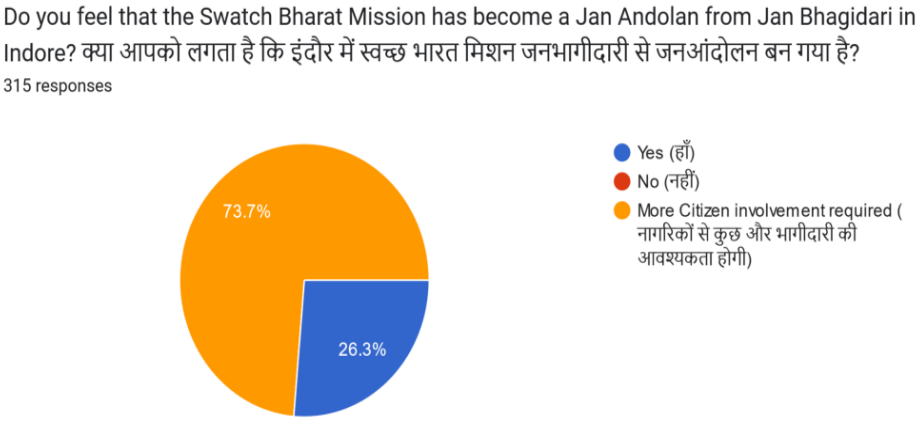
segregation has permeated down to grass root level as all agreed that the school going children were also aware about these aspects. This show the lengths to which the awareness campaign of IMC has percolated down in the population. The greater awareness would automatically lead to enhanced sustainability for future as these aspects introduced by the IMC would become a habit and part or way of life.

Figure 20: Awareness in children of Indore



Source: Response to Question No. 9

Figure 21: Jan Bhagidari in SBM (U)

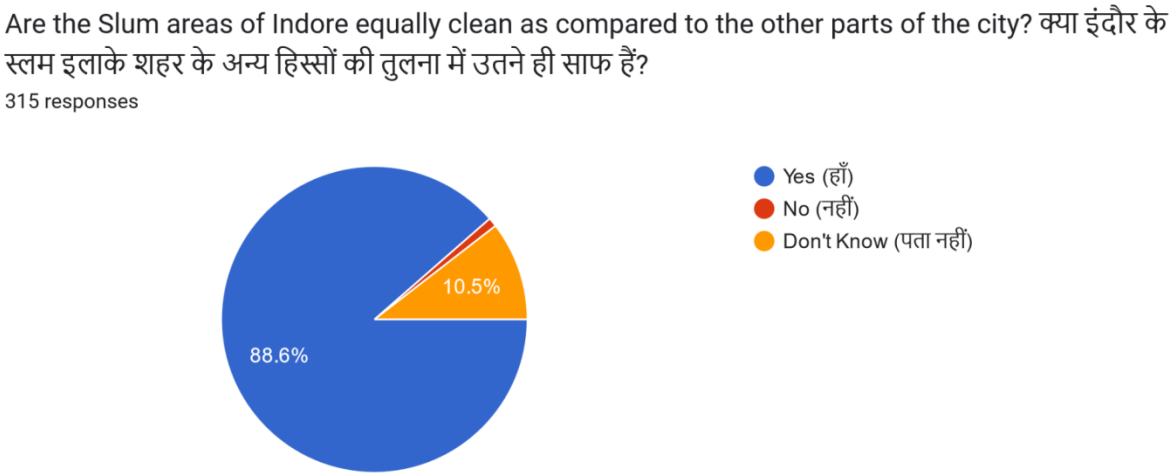


Source: Response to Question No. 10

On the question of whether the SBM has become a Jan Andolan from Jan Bhagidari. 73.7% of the residents responded by saying that more involvement of the citizens was required as not all were fully oriented towards the mission. Some of the

residents pointed out that since the city also has a floating population of 2.5 to 3 lakh, the people coming from outside the city in search of livelihood/ education are not fully conversant with the idea of segregation of garbage, no dumping etc and still there are a few places where some residents tend to dump garbage at times. This leads to a temporary situation wherein the IMC has to dedicate additional efforts towards clearing these temporary dump grounds. The residents brought out that it would be categorized as Jan Andolan when all are oriented towards one goal.

Figure 22: Cleanliness of Slum areas.



Source: Response to Question No. 11

Towards cleanliness of the slum areas, 88.6 % responded as that they are clean while 10.5 % responded that the areas are not clean. Visit to the some of the slum areas revealed that regular cleaning of the areas was taking place and the D2D collection of waste was being ensured by the IMC personnel as well as NGO supervisors who were present on-site. Public toilets were available in the vicinity of the slum areas which were also cleaned regularly. There were other ventures in vicinity as Neki ki Deewar which were utilized by the slum dwellers. However, there were some areas in the open that needed additional cleaning effort. On site sanitary workers brought out that with the provision of public toilets in vicinity of the slums there were no open defecation by the residents of these localities and that the city attained ODF++ status in 2023.

Inferences from Citizen Survey:

With the above questionnaire and the response obtained from 315 residents of Indore, it is clear that the population of Indore is well aware of the initiatives of the IMC and the changes that it has brought about in the city of Indore. The knowledge about remediation of the landfill and the knowledge of the waste to energy plants showcase the involvement of the residents in the cleanliness drive. Therefore it can be said that the Jan Bhagidari of the residents has resulted in the success of the cleanliness drive and has been one of the major reasons for its sustenance for seven years. The residents are also of the opinion that more needs to be undertaken both by the IMC as well as the residents towards ensuring that the status is maintained and the challenge of growing urban population of Indore and the challenges of MSWM are met by these steps.

8.3 Sustainability: Analysis

Officials and personnel of IMC, supervisors of NGOs, managers of processing plants and residents were interviewed. Also focused group discussions were conducted with the consultants, IMC SWM experts, NGO workers, Sanitary supervisors and Safai Mitras. The analysis of the interviews and discussions are as follows:-

Bureaucracy and Political Synergy

Good co-ordination between elected representatives and the executives of the IMC enhanced the MSWM in Indore. Indore residents as well as IMC personnel were of the opinion that vision of Mayor and efforts of the Municipal Commissioner were the causal factors that transformed the city. The successors of Indore Mayor and Commissioner continued with the legacy and made valuable contribution towards incorporating ICCC as well as Bio remediation of legacy waste. The residents and IMC personnel were of the opinion that Indore would be able to sustain its MSWM efficiently in future due to innovative methods of the IMC an participation by the people.

Changing Municipal Solid Waste Pattern

Table 10: Waste Generation Pattern

Year	***2014***	***2017***	***2023***
MSW (MTPD)	***1096***	***1115***	***1174***

Source: IMC

The interview with the SWM expert, IMC revealed a change in the pattern of waste generation in the city of Indore. The total waste generated was approx 1096 MTPD in 2014[50]. This waste comprised of approx 660 -700 MTPD of Dry and 450 MTPD of wet waste. However in 2023 the change in trend (as reported by the SWM expert of IMC) is that while the total waste was 1174 MTPD, Dry waste has reduced to 450- 500 MTPD and the wet waste has increased to 650-700 MTPD. Comparison of waste generation pattern of 2014 with 2023 indicates towards reversal in wet and dry waste pattern while the overall waste generation has marginally increased to 1174 MTPD in a span of 10 years. Further, the per capita waste generation per day in Indore is reported to be 397 gms/ person/ day as compared to 410 gms/ person/ day in 2014. While the generic pattern of increase in waste is 1.3% per annum, the reduced waste generation and changing pattern are indicative of changes in the waste generation habits of the Indore residents. This could be attributed to the various initiatives like Neki Ki Deewar, Bartanman, Jholaman, no disposable plates, no plastic bags etc. The innovative steps and firm implementation of policies has resulted in success of the concepts.

Analysis of the Changing Waste Pattern

However, it also needs to be kept in mind that there was no waste segregation in 2014 and all waste collected was mixed. This could be one of the reasons that dry waste was counted as higher than wet waste due to no clear segregation. Indore being a city of food loving people with a number of street food outlets and restaurants, wet/ organic waste is likely to be more than the dry waste after the initiatives of the IMC towards curtailing waste generation. In the coming years also there is likely to be an increase in the wet

waste/ organic waste generation as compared to dry waste. However with the increase in online procurement the packaging waste generated would certainly add to the overall dry waste generation.

Effect of Composting at Source

There is overall stagnation of total waste generated at approx 1096 – 1174 MTPD between the years 2014 to 2023. This may be attributed to the increase in home composting of wet waste and also processing of waste at source by the bulk waste generators. As per the SWM Rules 2016, the bulk waste generators have to process the wet waste at source through composting or Bio Methanation[51]. This rule has lead to processing of waste at the source itself and thereby reducing overall wet waste collection by IMC. In the year 2018, approximately 56,000 kg of wet waste was processed by home composting in Indore[52]. In addition to the home composting, there are 357 bulk waste generators in the city and 368 parks and gardens that follow the wet waste composting at site thereby ensuring processing of the entire wet waste generated by them. Since the exact figures are not available for analysis in regards to the waste being processed at source, the same may be undertaken in a future study on the subject.

Segregation of Waste leads to Efficient Processing

With the waste being segregated into six different types the processing of these has become efficient in Indore. The segregated waste is directly sent to respective processing plants and little effort is required at the GTS for further segregation. The SWM Rules 2016 clearly lays down the duties and responsibilities of the officials as well as waste generators and local bodies towards management of solid waste. Every waste generator has to segregate and store the waste separately and hand over to Municipal workers or authorized waste pickers. Enforcement of these rules has clearly made the difference wherein the waste is to be segregated at source, collection has to be from source and all the collected waste is to be processed separately as per the type of waste. Further the Industries (Cement, power plant etc) have to use RDF if located within 100 kms from the

solid waste processing (RDF) plants. As per the SWM 2016 rules, RDF quantity specified is 5 % of the total fuel used by the cement industries and power plants which has gradually increased to 25 % of the total fuel used. This increase has been beneficial to both the industries as well as ensured proper disposal of the dry waste. The segregation at the MRF is towards removing the recyclables from the dry waste. The segregated waste of biomedical, hazardous and sanitary are processed separately and disposed off. The segregated plastic waste is recycled as per its quality. The plastic that cannot be recycled has been used in construction of durable roads. The remaining wet and dry waste are pure waste that are processed at respective plants for Bio CNG generation or for creation of RDF. It is reported that dry waste recycling in India has potential for generating Rs 11,836 cr, composting can generate Rs 365 cr and Bio CNG can generate Rs 1679 cr annually[53].

Population growth and Projected Waste Generation.

As per the data of population growth of Indore the rate of growth is estimated at 3.2 % per year. The population of Indore in 2023 is 30 Lakhs, per capita waste generation is 405 gms/person/day. The rate of growth of per capit waste generation per year is reported to be 1.33%. With the annual growth rate of 3.2 % it is estimated that the population of Indore in 2031 2ould be 37.5 Lakhs and the per capita waste generation would be 444 gms. It is estimated that the total waste generated in 2031 would be 16.it is estimated that the total waste generation would be 16.65 MTPD by 2031. Projected increase of population and waste generation is given at Table 11.

Table 11: Indore projected population growth and MSW generation

Year	Projected population with growth rate @3.2% per year	Actual Population (Lakhs) as per IMC	MSW generation (MTPD)
2014	**2200000**	**22**	**1096**
2015	2270400	--	--
2016	2343053	--	--
2017	**2418030**	**27.5**	**1115**
2018	2495407	--	--
2019	2575261	--	--
2020	2657669	--	--
2021	2742714	--	--
2022	2830481	--	--
2023	**2921056**	**30**	**1174**
2024	3014530	--	--
2025	3110995	--	--
2026	3210547	--	--
2027	3313285	--	--
2028	3419310	--	--
2029	3528728	--	--
2030	3641647	--	--
2031	**3758180**	**--**	**1668 (Projected)**

Source: IMC

It may be noted that the waste generation since 2014 to 2023 has not increased @ 1.3% per year which is the accepted per capita waste generation growth rate in India[54] and has remained limited between 1096 MTPD to 1174 MTPD from 2014 to 2023. MoHUA report states that there has been a six fold increase in annual material consumption between 1970 to 2015, from 1.18 billion to 7 billion tonnes, and is expected to rise further to approx 14.2 billion tonnes by the year 2030[55].With increasing material consumption in the country, the MSW of Indore would also continue to increase with increase in population and purchasing power.

Processing Capability Vs Increased Waste Generation.

MSW generation would increase from 1174 MTPD in year 2023 to 1668 MTPD (projected) in year 2031. Additional processing requirements would depend on the gap between existing processing capability and increased MSW generation. The present distribution of wet and dry waste is 60 % and 40%. Is the same distribution is maintained in 2031, it would amount to 668 MTPD (Dry) and 1000 MTPD (wet waste).

The increase of dry waste may not pose major challenge with the existing processing as a major component of the dry waste is separated for recycling. The components of dry waste that are separated for recycling include rubber, metal, glass, textiles, shoes, plastic products, paper, cardboard etc. The NEPRA plant at Devguradia site has a capacity of processing 400 MTPD of dry waste. Out of the generated 1174 MTPD of total waste, dry waste is 400-450 which reduces further after segregation of recyclable materials. At NEPRA facility, dry waste is separated into 35 different categories; paper waste is segregated into three categories, plastic waste into 12 different categories, aluminum metal into separate categories of cans foils bangles etc. With this increased segregation, there is an overall reduction in the dry waste requiring processing. Items that cannot be recycled are processed to create RDF. This RDF is then utilized by the industries (Cement& power plants).

The present capacity of Wet waste processing (Bio Methanation) is 587 MTPD with the three plants of capacity 550 MTPD, 20 MTPD, 15 MTPD and additional 2 MTPD capacities at the star square GTS. With increased wet waste generation the processing capacity of 587 MTPD is likely to be exceeded. The solution would be to commission additional 100 to 150 MTPD capacity Bio CNG plant to support till 2031 along with increased composting at source (bulk waste generators, parks and large societies/ RWAs).

Management of Inert Waste

Inert quantity in 2016 was 30 % to 35 % of the total MSW, which was dumped at landfill sites. However in the year 2023, quantity of Inert has reduced to 5 % to 10 %. Even this is mixed in the RDF with additional <50 mm of processed dry waste added to retain the calorific value and utilised in cement fatories or power plants. The overall reduction in inert has been possible due to proper segregation of waste leading to efficient processing. At rpesent no inert waste is being sent to the landfills and this is a major step towards zero waste and zero landfill.

Integrated Management of Vehicles

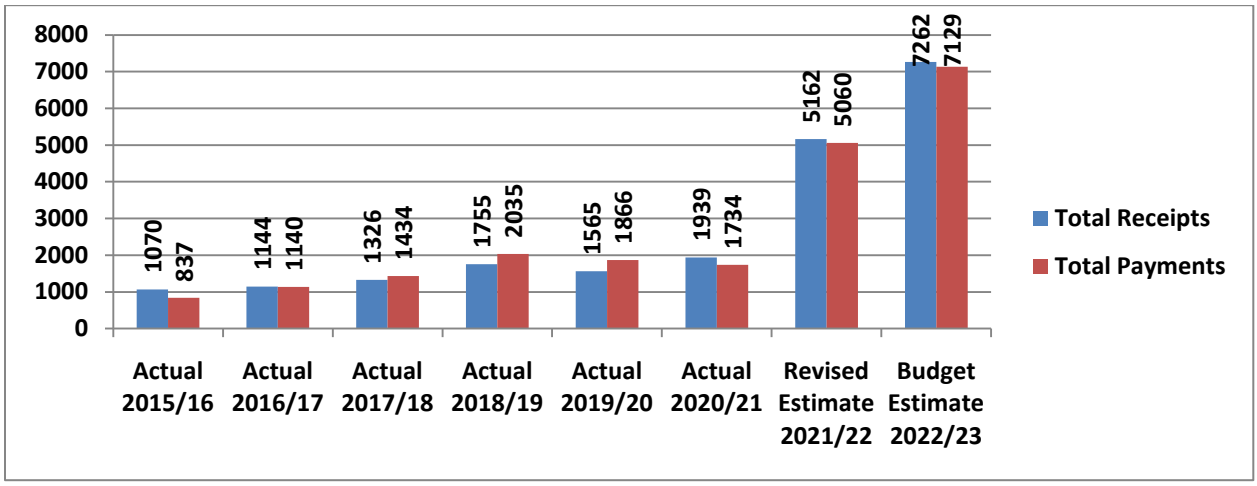
Provision of RFID, GPS tagging, communication and Integrated Command and Control Centre has resulted in efficient utilization of vehicles. Each vehicle makes t3-4 trips every day resulting in optimum utilization of vehicles and reduction in total cost of MSWM. There were 800 vehicles owned by IMC for MSWM in 2023. The process of outsourcing of vehicles would have entailed carriage charges of Rs 1400/Ton of waste in year 2015 and Rs 2500 in the year 2023. However, with use of own vehicles IMC is able to achieve the carriage @ Rs 800/Ton in 2015 and Rs 1200-1300/Ton in 2023. Due to this, IMC is still maintaining its own fleet of vehicles and has not outsourced the vehicles to any private vendor. The average life of these vehicles is approx for five years and requires replacement after that. Inspite of replacement of vehicles after every five years, the efficient management of vehicles has ensured that their operation is cheaper as compared to outsourcing of these vehicles.

Budget Management

The Budget of IMC has been increasing continuously every year to cater for new infrastructure, implementation of policies, incorporation of technology, meeting the aspirations of people and to delivering good governance. The IMC budget in terms of

Total receipts (Revenue + Capital) and total payments (Revenue + Capital) have been displayed in the table below.

Figure 23: Budget of IMC



Source: Budget at a glance IMC

Mayor of Indore presented budget of Rs 7473 Cr for the financial year 2023-24. Opposition leaders in the council pointed out that the budget of 7473 Cr for the year 23-24 was passed when the total earnings of the IMC are not more than 2000 Cr per year. With increase in overall budget of IMC, the budget for SWM would also be increased proportionally. Further, IMC has raised capital through sale of green bonds. The green bonds are being sold to generate approximately Rs 245 cr for building of a 60MW solar power plant for generation of electricity. With the commissioning of the plant Indore is likely to save approx Rs 25 Cr annually. These measures would help generate the funds as well as increase savings for IMC.

Milestones Achieved

IMC has achieved some major breakthroughs and crucial milestones in their journey of SBM 1.0 & 2.0 Some of the year wise milestones/ achievements of IMC are given at Table 12.

Table 12: Achievements/Themes IMC

Year	Achievements/ Themes
2016	D2D Segregation into Wet and Dry waste
2017	Segregation of Wet Dry and Plastic waste (3 Bin Vehicles) Ban on Plastic bags, Disposable plates, Bartanman and Jholaman concepts
2018	Reduce, Reuse, Recycle and Remediation of Devguradia Landfill. 100 acres land reclaimed. 10 acre park, 90 acre forest Home Composting
2019	6 Bin tipper vehicles NEPRA MRF
2021	Air Quality
2022	550TPD Bio CNG Plant
2023	Zero landfill

Source: IMC

Picture 15: Dry and Wet waste processing facility NEPRA MRF & Gobardhan Bio CNG plant

Source: Author's personal collection

Jan Bhagidari towards Sustenance

The Jan Bhagidari or people's participation in the cleanliness drive is increasing and IMC is receiving good support from the population. The Indore residents feel responsible towards waste segregation and depositing the segregated waste in the tippers. The music played by the tipper vehicles is an indicative of its approach in the locality. Further, since the timings and crew are fixed the vehicles arrive every day at the same time. In addition to the tipper vehicles the CSI and Asst CSI are also present in the vicinity of the collection vehicles and are ready to provide solution to any issues that crop up. The

residents have also taken to the household composting in a big manner and all the people who have kitchen gardens are making good use of the composters provided by the IMC. One such individual Rajendra Arzare was interviewed who explained the entire process of home composting and how the residents are increasingly becoming involved in the SBM 2.0.

Picture 16: D2D collection at Sukhliya locality

Source: Author's personal collection

Picture 17 Mr Rajendra Arzare explaining home composting for his rooftop garden

Source: Author's private collection

Chapter 9

Conclusion & Recommendations

9.1 Recommendations

Towards sustaining the efficiency of MSWM at Indore, IMC needs to cater for certain important aspects. Few recommendations are made towards ensuring sustainability of the MSWM at Indore city:-

- Increase in wet waste processing capability (Bio CNG) by at least 100 to 150 MTPD.
- Increase in composting capability to cater for the gap in wet waste processing and wet waste generation.
- Promotion of organic farming and use of compost in villages and farms in vicinity of the city.
- IEC campaign for use of organic compost in agriculture needs to be carried out to sensitise the farmers of using compost as the fertilizers.
- To create/ promote market for organic farm products and outlets in the city thereby ensuring increase in organic farming and consumption of compost.
- Market and consumer base needs to be expanded for sale of compost. Government (Department of Fertilizers & Chemicals) may provide assistance in terms of promoting compost in comparison to chemical fertilizers. This would increase the demand and therefore make the composting an economically lucrative option.
- Open grounds and fields need to be cleared of litter thereby providing a clean look to the city especially in vicinity of slum areas and prevention of littering of fields and grounds.
- Conversion of slums into planned societies would aid in MSWM in these areas.

- Increased involvement of school children in various IEC campaigns would ensure increased Jan Bhagidari in all aspects of MSWM
- Zero waste and Zero landfills to be actively pursued and achieved.
- Provision of incentive of segregating recyclables from dry waste at source would ensure that the recyclables do not become part of the dry waste requiring segregation at a later stage. This would increase the quantity of recyclables and reduce the overall dry waste generation.

9.2 Conclusion

SBM 1.0 and 2.0 have propelled the cleanliness drive in the entire country. While a number of cities are gradually making their mark, Indore has been able to undertake numerous innovative and revolutionary steps in a short time frame towards transforming the city and has maintained the cleanest city in India status for seven continuous years. It has been a collaborative effort of the bureaucracy, political will and most importantly whole hearted participation by the population of Indore. All the new schemes initiated by IMC officials and the mayor of Indore have been well supported by the residents of the city. Therefore, the most important aspect in this scheme is not only the incorporation of innovative measures and technology; it is also of Jan Bhagidari wherein the citizens have undertaken strict measures towards successful implementation of the schemes. With the rapidly growing population and increased MSW generation, IMC needs to be constantly incorporating new technologies for efficient MSWM.

The increase in population at rate of 3.2% per year and the resulting increase in MSW generation (1.33% per capita per year) would pose a challenge for IMC in terms of waste handling and processing capacity in future. With enhancement of technology and efficient waste to energy plants, processing of waste would be a profitable venture. This would enhance the participation of private firms in the MSWM and thereby increase efficiency as well as bring in new technologies. The journey of IMC since 2016 has provided it with valuable inputs and experience towards all aspects of efficient MSWM. The experience gained by the IMC would assist in sustainability in future. The existing

model of MSWM at Indore is likely to be sustainable in future due to the achievements and pursuance of IMC goals in line of the SBM 2.0. The clean Indore initiative of IMC has become a whole of government and peoples approach. This initiative is a combined effort of the political, bureaucratic and the people of Indore. Cleanliness drive has become second nature to the residents of the city and MSWM plays a very important aspect in achieving the cleanliness status. As the IMC progresses into other initiatives of providing clean and green energy and value services in terms of clean drinking water, supply of fresh water, treatment of sewage and other public services, MSWM would continue to remain an important step towards achieving the clean Indore initiative. The achievements of IMC that would ensure sustainability of this initiative in future are as listed below:-

- 100% Segregation, 100% D2D collection, 100% processing
- Zero landfills in the city after Remediation of legacy waste
- No dumping grounds and secondary bins
- Processing plants and waste to energy plants
- Jan Bhagidari becoming Jan Andolan
- Integration of technology (ICCC and 311 App) in MSWM
- Capacity Building for personnel and IEC for citizens

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