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Solid Waste Management and Municipal Corporation's role; Case Study of Nagpur, India

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Abstract- **India is the second largest nation in the world, with a population of 1.39 billion, accounting for nearly 18% of world's human population, but it does not have enough resources or adequate system in place to treat its solid wastes. Its urban population grew at a rate of 31.8% during the last decade to 377 million, which is greater than the entire population of US, the third largest country in the world according to population. India is facing a sharp contrast between its increasing urban population and available services and resources. Solid waste management (SWM) is one such service where India has an enormous gap to fill. Proper municipal solid waste (MSW) disposal systems to address the burgeoning amount of wastes are absent. The current Solid waste management services are inefficient, incur heavy expenditure and are so low as to be a potential threat to the public health and environmental quality. Improper solid waste management deteriorates public health, causes environmental pollution, accelerates natural resources degradation, causes climate change and greatly impacts the quality of life of citizens**

Keywords- Solid Waste, Generation, Collection, Solid waste management,Composting,Disposal ,Waste Characterization

I. INTRODUCTION

The present citizens of India are living in times of unprecedented economic growth, rising aspirations, and rapidly changing lifestyles, which will raise the expectations on public health and quality of life. Remediation and recovery of misused resources will also be expected. These expectations when not met might result in a low quality of life for the citizens. Pollution of whether air, water or land results in long-term reduction of productivity leading to a deterioration of economic condition of a country. Therefore, controlling

pollution to reduce risk of poor health, to protect the natural environment and to contribute to our quality of life is a key component of sustainable development.

The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011, fuelled by changing lifestyles and increased purchasing power of urban Indians. Urban population growth and increase in per capita waste generation have resulted in a 50% increase in the waste generated by Indian cities within only a decade since 2001. There are 53 cities in India with a million plus population, which together generate 86,000 TPD (31.5 million tons per year) of Municipal solid waste at a per capita waste generation rate of 500 grams/day. The total Municipal solid waste generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of Municipal solid waste. Such a steep increase in waste generation within a decade has severed the stress on all available natural, infrastructural and budgetary resources.

FIGURE NO.1 (IMPACT OF IMPROPER SWM ON PRISTINE ECOSYSTEMS, LANDFILL)

Big cities collect about 70 - 90% of Municipal solid waste generated, whereas smaller cities and towns collect less than 50% of waste generated. More than 88% of the Municipal solid waste collected formally is land filled on open lands and dumps. It is estimated that about 2% of the uncollected wastes are burnt openly on the streets. About 10% of the collected Municipal solid waste is openly burnt or is caught in landfill fires. Such open burning of Municipal solid waste and landfill fires together releases 22,000 tons of pollutants into the lower atmosphere of Mumbai city every year. The pollutants include carbon monoxide (CO), carcinogenic hydro carbons (HC) (includes dioxins and furans), particulate matter (PM), nitrogen oxides (NO_x) and sulfur dioxide (SO2).

Municipal Corporation Role:

Municipal solid waste rules 2000 made by the Government of India to regulate the management and handling of municipal solid wastes (MSW) provide a framework for treatment and disposal of Municipal

solid waste. These rules were the result of a 'Public Interest Litigation (PIL)' in the Supreme Court of India (SC). The MSW rules 2002 and other documents published by the Government of India (GOI) recommend adoption of different technologies, which include biomethanation, gasification, pyrolysis, plasma gasification, refuse derived fuel (RDF), waste-to-energy combustion (WTE), sanitary landfills (SLF). However, the suitability of technologies to Indian conditions has not been sufficiently studied, especially with regard to the sustainable management of the entire municipal solid waste stream and reducing its environmental and health impacts.

Due to lack of data and infrastructural, financial and human resources, the Supreme Court mandate of complete compliance to the rules by 2003 could not be achieved by urban local bodies (ULBs) and that goal still remains to be a distant dream. As a result, even after a decade since the issuance of the Municipal solid waste Rules 2000, the state of Municipal solid waste management systems in the country continues to raise serious public health concerns. Although some cities have achieved some progress in Solid waste management, many cities and towns have not even initiated measures. Initiatives in Mumbai were the result of heavy rains and `consequent flooding in 2006 due to drains clogged by solid waste. The flood in Mumbai in 2006 paved the way for enacting State level legislation pertaining to the collection, transport and disposal of urban solid waste in the state of Maharashtra. Bubonic plague epidemic in Surat in 1994 increased awareness on the need for proper Solid waste management systems all over India and kick started measures to properly manage wastes in Surat.

The study also found that open burning of solid wastes and landfill fires emit nearly 22,000 tons per year of pollutants into the air in the city of Mumbai alone. These pollutants include Carbon Monoxide (CO), Hydrocarbons (HC), Particulate Matter (PM), Nitrogen Oxides (NOx) and Sulfur Dioxide (SO2) plus an estimated 10,000 TEQ grams of dioxins/furans. Open burning was found to be the largest polluter in Mumbai, among the activities that do not contribute any economic value to the city. Since open burning happens at ground level, the resultant emissions enter the lower level breathing zone of the atmosphere, increasing direct exposure to human.

Story of Nagpur, the Orange City of India:

Nagpur is the third largest city in the state of Maharashtra after Mumbai and Pune and is the largest city in central India. Nagpur is also being developed as a Smart City under the Government of India Smart City programme. Nagpur is the geographical center of the country and is the major trade centre in the region and is well connected. Nagpur Municipal Corporation (NMC) spreads over an area of 227.38 sq. km with a total population of 24.06 lakh (2.4 million) according to the census of 2011. Nagpur city makes up 4.73% of the total urban population of the state. The city is now among the fastest growing cities in India and is rapidly emerging as commercial, retailing and logistic hub.

Population Density

The overall liveability of a place is dependent on the population density of that place. In case of Nagpur, according to the 2011 Census, the population density is 10,580 persons/ sq.km (density 106 persons per hectare (pph)). The average population density of Nagpur city is on the lower side of the permissible limits as given in the Urban Development Plan Formulation & Implementation (UDPFI) guidelines for metropolitan cities (125-175 pph).

Literacy Rate

The literacy rate reflects the socio-economic development of any region. Nagpur city has the highest literacy rate of 91.92% when compared to the district, state and urban India literacy rate. The high literacy rate can be attributed to Nagpur city being one of the leading centres of higher education in the state.

Solid Waste Management is todays emerging issue for the safe environment and healthy life. The primary goal of solid waste management is reducing and eliminating adverse impact of waste on human health and environment to support economic development and superior quality of life. Waste generation has increased day by day due to increasing population, industrialization and urbanization.

According to a survey by ABP News-Ipsos, Nagpur was identified as the best city in India topping in livability, greenery, public transport, and health care indices in 2013.The city was adjudged the 20th cleanest city in India and the top mover in the western zone as per Swachh Sarvekshan 2016. It was awarded as the best city for innovation and best practice in Swachh Sarvekshan 2018. It was also declared as open defecation free in January 2018 under Swachh Bharat Mission. It is also one of the safest cities for women in India. The city also ranks 31st in Ease of Living index among 111 cities in India.It was ranked the 8th most competitive city in the country by the Institute for Competitiveness for the year 2017.

According to the provisional census data for the year 2011, Nagpur City's total population is 24.06 lakh (2.4 million). There has been an almost threefold growth in the population in the last four decades, from 8.66 lakh (0.87 million) in the year 1971 to 24 lakh (2.4 million) in the year 2011.

Chronological development of Nagpur city –

Nagpur city is named after the River Nag and has been known since prehistoric times. Nagpur and its surrounding region are also mentioned in the Vedic and Mauryan scriptures. Nagpur city was founded by the Gond King of Deogad "Bakht Buland Shah" in the year 1703. In 1743, it became the capital of Raghoji Rao Bhonsle's kingdom.

Awareness of planned city development was raised by Sir Patrick Geddes, who visited the city in 1915. The Nagpur Improvement Trust (NIT) was established in 1936 to carry out planned development in the city. The British Government made

Nagpur the capital of the new state named Central Province in the mid-19th century and it remained so until 1956, after which it became the second capital of Maharashtra. Nagpur enjoyed the status of being the administrative center of Central India during the ancient and medieval eras. It boasts a legacy of cultural and economic prosperity. Its proximity to tribal areas has also ensured the preservation of its natural resources, i.e. minerals and forests.

II. WASTE QUANTIFICATION & CHARACTERISATION

Waste Quantification:

Municipal Solid Waste (MSW) quantification for Nagpur has been estimated based on the past records of waste transported to the dumpsite by NMC. A truck scale of 30 tonne capacity is installed at the existing dumpsite at Bhandewadi to scale all incoming waste coming to the dumpsite prior to processing or disposal. A detailed analysis of the weighbridge data for the last two years from April 2015 to March 2017 has been carried out to estimate waste generation for Nagpur. Based on the available weighbridge record, approximately 14,000 tonnes of waste reached the dumpsite in 2016 –17 (April-March), and 13,300 tonnes in 2015-16 (April-March). The average daily collection of waste based on the weighbridge record for last two years is 1,119 tonnes per day.

Waste Characterisation:

A waste characterisation exercise for Nagpur city was undertaken by the National Environmental Engineering Research Institute (NEERI), Nagpur. A total of 34 samples were collected from all the 10 zones in the city. Reconnaissance survey and fieldwork was carried out April/Mai, 2017. The locations for waste sampling were selected to provide representative characteristics of wastes at the source of generation, at secondary collection points, and at the disposal site. For this purpose, reconnaissance survey was undertaken and the location of the sampling points was identified based on stratified random sampling method to represent different waste generation sources such as residential (slum and non-slum areas), secondary collection points/ community bins, institutional areas, commercial establishments and, finally, at the disposal site.

III. EXISTING SWM SYSTEM IN NAGPUR

Nagpur Municipal Corporation (NMC) is currently generating an average of 1100-1200 TPD of waste, with an average per capita generation of 444 grams per person per day. NMC has been a progressive urban local body and has taken some measures for improvement of waste management in the city; however, there is still a need for a lot of focus and considerable improvement. According to the Swachh Sarvekshan5 survey, 2017, a survey to rank 500 cities in India on the basis of cleanliness and other aspects of urban sanitation initiated by the Ministry of Urban Development, Government of India, Nagpur ranked 137 out of a total of 434 cities surveyed, with an overall score of 1158 as against Navi Mumbai (1705), the top-ranked city in Maharashtra and Indore (1808) the top-ranked city in India.

For solid waste collection and transportation, Nagpur scored 293 as against Greater Mumbai (360), the topranked city in Maharashtra and Imphal (360), the top-ranked city in India in this category. Some of the initiatives by Nagpur city include privatisation of waste collection and transportation services, which involves the collection of waste from doorsteps and transportation to the dumpsite. In the year 2008, Nagpur city came up with the concept of a bin-free city and eliminated more than 80% of primary collection points/ community bins from the city. There is still scope for improvement in the collection and transportation system, including improvements in logistic management, optimal utilisation of vehicles, increasing coverage of outer city areas, and bringing efficiency to segregation practices.

For solid waste processing and disposal, Nagpur scored 82 as against Pimpri-Chinchwad (180), the topranked city both in Maharashtra and in India in this category. This indicates that there is surely a requirement to improve the overall processing and disposal system for waste in the city. There was previously some initiative for the processing of waste in the city, which includes setting up a waste to RDF facility with support from a private operator. However, the facility is not currently in operation.

In addition, a waste bioremediation project primarily for the existing waste is being practiced by the city on the existing dumpsite. According to discussions with the city officials, the project has managed to considerably reduce the height of the existing waste dump. However, the project and technology is currently under question and facing challenges because of recent incidences of a huge fire (March 2017) and odour issues. Other initiatives by the city include the signing of a contract with a private operator for setting up a new waste-to-energy facility.

Despite the above efforts, the processing and disposal of waste in Nagpur requires much higher level of attention to make it compliant with the Solid Waste Management Rules, 2016 (SWM Rules 2016), Ministry of Environment, Forest and Climate Change, Government of India. The existing dumpsite at Bhandewadi is open and subject to various risks due to fire, leachate percolation, emission and is certainly a health and safety concern for the people working on-site as well as people residing along the edge of the dumpsite.

(A big dump of garbage at Bhandewadi dumping yard caught fire. Image courtesy- The Hitavada 14th April, 2020)

The city of Nagpur, located at the geographical centre of the country has a population of 2.5 million spread across an area of 217 sq.km. It is estimated that the city generates approximately 900-1000 tonnes of waste per day (TPD). Also, the city being an educational hub attracts large floating population. Rapid growth of population coupled with urbanization has put tremendous pressure on Nagpur Municipal Corporation to meet the growing demands of its citizens. However, despite its limited infrastructure, manpower and financial resources, the city is adopting best feasible options to provide adequate services. The door to door collection of waste for the city is outsourced to private contractors"Anthony Wastes" and"Bharat Vikas Group (BVG)". Earlier it was outsourced to Kanak Resources Management Ltd. from year 2008 to 2020 who was also responsible for transporting the waste to landfill site at Bhandewadi. However, the door to door services covers only 5 lakhs of household against the population of 2.5 million. In year 2010, NMC had contracted a private entity 'Hanjer Biotech' to commission and operate the waste processing and disposal facility. However, only 150-200 TPD of waste is being treated and processed at the facility while remaining 800 TPD is dumped at the site. In the last few years, almost 4 lakhs MT of waste is dumped at the Bhandewadi Site. Odour, flies and leachate seeping into the ground is a common sight at the landfill thereby threating the environment and public health, especially for people residing in the vicinity. The city is facing significant challenges in addressing the system's deficiencies and reducing the environmental impacts due to unscientific solid waste management. The city of Nagpur is poised to develop as a 'Smart City', with support from the Smart Cities Mission of the Government of India. The overall vision of the smart city proposal developed by NMC, aims to create an inclusive ecosystem. This above mentioned scenario and vision of NMC highlights and supports the need for a holistic approach towards waste management, integrating the existing silos to overcome issues related to capacity at local level, waste segregation, waste management, technical knowhow and stakeholder involvement. Therefore, it was decided to conduct a detailed study on waste management of the City focusing on suitable technologies for processing the waste.

Considering the present scenario of waste management in Nagpur, especially the limited processing facility of municipal solid waste taking place, it was decided to provide advisory services to NMC under Urban Nexus project. The idea is to help NMC to choose the best processing technology to treat its waste depending upon its economical and environmental viability, social acceptability and sustainability. The study will help the city to make a well-informed decision while selecting an appropriate technology that would also promote maximum resources utilization, improved efficiency and hence a step towards circular economy. Nagpur Municipal Corporation (NMC)

IV. COLLECTION& TRANSPORTATION:

Primary Collection-

For the effective management of waste, the city has been divided into 10 zones. Door-to-door waste collection is practiced in all wards, except outer city areas. NMC has privatised collection and transportation of the solid waste and awarded the contract to "Anthony Wastes" and "Bharat Vikas Group (BVG)". They both are responsible for the door-to-door collection of waste and transportation of waste to the dumpsite at Bhandewadi.

DIFFERENT ZONES OF NAGPUR CITY

SN.	AREA	DETAILS OF NAGPUR CITY
01	Population	27,10,040 (Present)
02	House Holds	4,96,620
03	Shops and offices	75,193
04	Zones	10

05	Wards	136
06	Waste Generation	1189 TPD (Average March 2017)

Segregation of Waste-

SWM Rules 20166 prescribe source segregation of waste, i.e. segregation of waste by the generators but, as of now, segregation of waste at source is not practiced by the generators. Segregation of waste (limited to recovery of high value recyclables) is practiced by the workers engaged in door-to-door collection of waste. High value recyclables such as plastics, metals, papers, etc. are separated by the workers involved in doorto-door collection which provides them with additional income. Continuous efforts are required by NMC and KRML to implement source segregation and to raise awareness among the citizens for implementation of the same.

Street Sweeping-

Street sweeping and drain cleaning is done by in-house staff of NMC. The total length of road for street sweeping is about 3,400 km. Street sweeping operations are carried out in the morning and evening in two shifts, i.e. 6.00 am to 11.00 am, & 3.00 pm to 6.00 pm. An average street length of 700 m (max 900 m and minimum 500 m depending upon the density of the population) per worker is swept daily.

Handcarts are generally used by sweepers for transporting silt from roads and open drains. The solid waste collected from road sweeping & drains are transported to the nearest collection centre for further transportation and disposal to the dumping site by KRML At present, 8200 NMC staff are involved in road sweeping and drain cleaning.

Approximately 44% (3613) are on regular roles and the balance 56 % (4587) are contract employees. The key issue associated with street sweeping in Nagpur is low supervisory staff and lack of proper supervision by the existing supervisory staff.

Secondary Storage System-

Nagpur had adopted the concept of a "Bin-Free City" as far back as 2008, which resulted in a significant reduction in the number of community bins from 700 in 2008 to 170 in 2017 (approximately 80% reduction). Bins/secondary collection points are provided only in the areas with continuous commercial activity. In addition, there are 9 transfer stations earmarked in various zones, which also serve as secondary storage points. The transfer station in zone 3 is mechanised, whereas the transfer stations in other zones are nonmechanised and open, resembling a large waste storage point.

Waste Transportation System-

Waste transportation in Nagpur is privatised with KRML providing the infrastructure and service for transportation of waste to the Bhandewadi dumping site. The vehicles deployed for transportation include tipper trucks of various sizes, dumper placers and compactors. Waste from the smaller vehicles utilised in primary collection is transferred to the larger vehicles for further transfer to the dumpsite. Transfer stations developed in various zones are utilised for optimising vehicle utility and bringing more efficiency to operations. Approximately 300-325 trips per day are made to the Bhandewadi dumpsite, with each vehicle making 3-4 trips per day.

In 2015, NMC started developing the Geographic Information System (GIS) based-route map for waste collection and monitoring. The system was developed to bring efficiency to collection and transportation, including proper utilization of manpower, saving of fuel, reduction of time and ensuring regular collection of waste. Currently, the GIS-based monitoring system has been adopted in only a few zones and is being utilised for tracking of the vehicles involved in collection & transportation of solid waste.

Treatment System-

Currently, there is no working waste treatment facility in Nagpur. Waste collected from various parts of the city is dumped at Bhandewadi dumpsite, which is approx. 10 km from the city centre. In the year 2009, NMC awarded the work of treatment and processing of municipal solid waste to M/s. Hanjer Biotech Energies Pvt. Ltd., Mumbai. Approximately 11 acres of land was leased to M/s.Hanjer Biotech Energies Pvt. Ltd. for development of the composting and Refuse Derived Fuel (RDF) based processing facility. The contract was awarded on a Build, Operate and Transfer (BOT) basis for 12 years. The first two years were for construction and development, and the remaining 10 years for operation and maintenance. The total capital cost for the project was Rs. 26 crores (Euro 3.60 million) and the tipping fee paid by NMC was Rs275 (Euro 3.81) per tonne.

After a major fire incident in the plant in 2012, which destroyed a major part of the segregation unit & machinery, the plant became non-functional.

NMC also started processing legacy waste along with some fresh waste using bioremediation/ bio-mining technology at the existing dumpsite (since January 2017). A total of 311 windrows of five to six feet in height were created from approximately 600,000 tonnes of garbage. The process involves the bio-mining of waste, followed by segregation and harrowing of waste and spraying of biocultures to accelerate degradation. According to the NMC officials, the process has been successful in reducing the height of the existing dumpsite to some extent. However, a lack of market for compost and soil derived from the process has affected the project. Also, recent incidences of a huge fire

(March 2017) and odour issues have questioned the reliability of the project.

In May 2017, NMC signed a contract for the development of a waste-to-energy facility of 800 TPD at the Bhandewadi dumpsite. M/s. Essel Infra Projects Ltd. Mumbai and Hitachi Zosen India (JV) have been selected as concessionaires for the project. The project is based on mass burn incineration technology and is expected to generate 11.5 MW of electricity. The scheduled commissioning date for the project is June 2019 and the total contract duration is 15 years. The estimated project cost is 251 crores (Euro 35 Million), of which Viability Gap Funding (VGF) of INR 70 crore (Euro 9.7 million) is being provided by the central government under Swachh Bharat Mission7 and the balance is to be invested by the private concessionaire. The estimated tipping for the project is Rs 225 (Euro 3.12) per MT, with an annual increment of 4.5% along with an electricity tariff of Rs 5.86 (Euro 0.08) per unit.

Disposal System-

The Bhandewadi dumpsite is an open dumpsite in Nagpur, spread over 22 hectares or 54 acres of land. The site is surrounded by habitation on three sides (east, north and west), a sewage treatment plant to the southeast, and a composting and RDF plant developed by Hanjer to the south. The approach road to the site is also from the south end of the site.

The Bhandewadi dumpsite has been in operation since the year 19668 and has been earmarked as a compost yard in all the development plans for the city since then. It is estimated that more than 18,00,000 MT of waste has been dumped on the dumpsite since its inception. However, no actual record of waste dumped at the dumpsite is available with NMC. In the year 2011, a part of the waste from the dumpsite was shifted and capping was provided over an area of 40,630 sqm (4 ha). The balance area is currently being used for the disposal of waste.

(Fig.1.2 The Bhandewadi dumpsite is an open dumpsite in Nagpur)

NMC has earlier constructed a cell for the safe disposal of rejects from MSW processing on the existing dumpsite. However, during the site visit, the sanitary landfill cell was observed to be non-operational. The waste is currently dumped indiscriminately with minimal compaction and no daily cover, having no system for collection or treatment of leachate leading to likely contamination of the soil and ground water resources. Many secondary studies9 have indicated a higher level of ground water pollution in the area surrounding the Bhandewadi dumpsite. The dumpsite is subject to frequent fires during the summer season and has been causing air pollution, odour nuisance and have an adverse health impact on the nearby residents. Recently, there was a major fire outbreak on the dump site in March 2017, which has raised questions about the operations of the dumpsite.

The infrastructure provided at the dumpsite include a weighbridge of 30 tonne capacity, concrete roads, street lights and a boundary wall which is broken and dilapidated at various places, leading to unauthorised access to the site. NMC has deployed one front end loader, one excavator and one dozer at the dumpsite. Manpower at the site includes one sanitary inspector, two supervisors and twenty-six labourers of NMC. According to the discussions with the site in charge, approximately 150 -200 ragpickers collect recyclables from waste on dumpsite. However, no proper record or data on the number of ragpickers and the quantity of recyclables collected is available from the NMC responsible.

The ragpickers on the dumpsite are subject to various health and safety related hazards, which include injury and infection due to sharp objects, health impact by continuous exposure to waste, and accidents due to vehicles operating on-site.

There is no major programme currently for rehabilitation of ragpickers from the site. There are some reports available from secondary sources on providing personnel protective equipment and vocational training to ragpickers by various NGO's, including the Melinda Gate Foundation in the past. However, during actual discussion with selected ragpickers on-site, this could not be confirmed.

VII. CONCLUSION

India energies problems have made the need to turn towards waste to energy technologies extremely important. Especially because landfills in India urban centers are fast nearing the limits of their capacity.

For better management of solid waste, periodic review of each steps involved in waste management like generation, collection, disposal etc. should be conducted & accordingly implementation of "Best Practices" is necessary.

Best practices for waste management can be achieved by well known '3R's principle (Reduce, Reuse and Recycle). Wet garbage from hotel, resident can be recycled by establishing composting or vermicomposting plant in the vicinity. This will produce good manure that can be used

for gardens and lawns. The least technically complex and most cost-effective solution should be chosen.

Local Bio-degradable waste processing units, wherever possible set up small scale processing units (composting or biomethanation) in public parks, playgrounds, recreation grounds, gardens, markets. Waste should be also seen as a 'resource' and not just a problem. This indeed should be carried out by government and every individual residing in the city to bring Nagpur to the first position as a green city. Preventing a good and clean environment today can lead to a better tomorrow.

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