

# Sustainable Solid Waste Management; Case study of Nagpur, India

Chandramani Bhimrao Patil\*, Dr. Arif Khan\*\*

\* Environmental Engineering Department; Nuva College of Engineering & Technology Nagpur, India

\*\* Environmental Engineering Department ; Nuva College of Engineering & Technology Nagpur, India

**Abstract-** Nagpur is the third largest city and the winter capital of the Indian state of Maharashtra. It is the 13th largest city in India by population and according to an Oxford Economics report, Nagpur is projected to be the fifth fastest growing city in the world from 2019 to 2035 with an average growth of 8.41%. It has been proposed as one of the Smart Cities in Maharashtra and is one of the top ten cities in India in Smart City Project execution. Rapid economic growth, increasing population and change in living standards of city causes a high generation rate of different forms of wastes. Waste management and treatment is a major problem faced by municipal bodies all over the world especially in India. There are no specific centres for the disposal of e-waste and medical waste. Waste management techniques are not up to the mark as far as the increasing population of the city is concerned.

This case study has discussed the sustainable solid waste management in Nagpur City, Maharashtra, India.

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

## I. INTRODUCTION

Nagpur is the winter capital and the third largest city of Maharashtra and largest city of central India. It has one of the highest literacy rates of 91.92% among all the urban agglomerations in India. NMC divides city in 10 zones and each zone is divided into several wards. As per provisional reports of Census India, population of Nagpur in 2011 was 2,405,665; of which male and female are 1,225,405 and 1,180,260 respectively (Census Nagpur, 2011). Nagpur ULB has received a credit rating of 'A' by CRISIL in 2012. The city is located in centre of India at a distance of 1065 km from Delhi and 825 km from Mumbai. Nagpur is well-connected with a number of major cities of India via Air, Trains and Roads.

Solid Waste Management is today's 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.

The most important point in which we are lagging in implementation of waste management projects is public unawareness. People in Nagpur are not aware about segregation of household waste which is main step involved in waste management. In this paper, we have given the various types of waste generated under solid

waste, their contribution in total waste generated, current news related to upcoming projects. Solid waste is categorized as household waste,

electronic waste and biomedical waste. The household waste contains food, paper, plastic, glass waste etc. In India, the 45% of waste is biodegradable, 13% is electronic waste, 11% is metal & glass and about 13% of waste consist of inert materials.

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 top-ranked 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 top-ranked 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.



( Fig. 1.1 landfill site at Bhandewadi)

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 a private contractor (Kanak Resources Management Ltd) since 2008 who is 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. Odor, flies and leachate seeping into the ground is a common sight at the landfill thereby threatening 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 Kanak Resources Management Limited (KRML) in December 2007. KRML is responsible for the door-to-door collection of waste and transportation of waste to the dumpsite at Bhandewadi.

The current contract for KRML expires in May 2018. The vehicles deployed for door-to-door collection activities include handcarts, tricycle rickshaws, auto tippers, and small trucks (Tata 407). Under the "Bin-Free City" programme of NMC, a number of community bins have been reduced and eliminated and most of the garbage collected from various residential, commercial and institutional areas is directly transferred to the waste collection and transportation vehicles, which act as moving waste receptacles. The door-to-door collection service does not cover the outer city areas and a few congested localities in Nagpur.

The service is constrained by the reduced level of service standards and regularity. During a field visit, the study team recorded complaints from citizens about garbage spillage and related issues, and limited primary collection was observed in the following localities:

1. Rajeev Nagar, part of Kachipura in zone I,
2. Gond toli, Marar toli, New Futala Basti in zone II,
3. Kafala Basti in zone III,
4. Takiya Dhantoli in zone IV,
5. Shantinagar, Telipura in zone VII,
6. part of Pardi area, Satranjipura in zone VIII, and
7. Matatoli Basor Basti, Balabhaupt, Korali, Mankapur, Gaddigudam in zone IX.

##### **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 door-to-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 non-mechanised 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 Mission<sup>7</sup> 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 studies<sup>9</sup> 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.

### V. SAMPLING OF MSW

Waste samples were collected from all 10 zones of Nagpur city and the general procedures followed for waste sampling for the project are presented below.

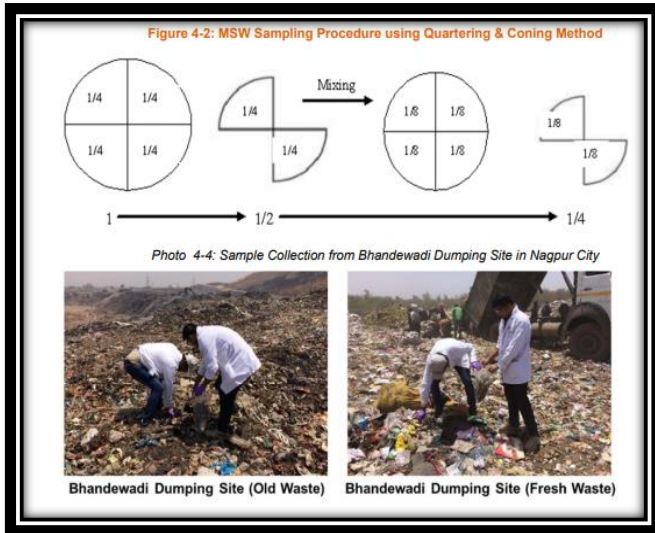
- Identification of major sample collection points from all 10 zones representing different types of waste generation sources, such as residential, commercial, markets (vegetable market) and slums. The economic status of the areas, representing high, middle and low-income groups, was also taken into consideration during the selection of sampling locations.

- 5 kg of waste were collected from each identified point and mixed thoroughly to get a homogenous sample. The quarter and coning method recommended in the Manual for Municipal Solid Waste Management, 20164(CPHEEO ) was used for sampling.

- The physical composition of MSW was determined at the site itself. The collected samples were separated into various major components, such as, paper, glass, plastics, etc. and weighed and expressed as a percentage of the original sample.

- For chemical analysis, the samples were packed in a plastic bag, sealed and sent to the NEERI laboratory. Each sample was in the range of 1-2 kg.

- The size determination of the samples was done using a sieve of 150 X 150 mm.



(Fig.1.3 MSW Sampling Procedure)

Waste composition from the dumpsite is shows approximately 40 % of organics, followed by plastic (18%) and paper (11%).The organic content at the dumpsite is slightly lesser than the composition of waste collected from the residential area, institutional & commercial areas due to mixing of street sweeping and drain cleaning waste at the dumpsite.



(Fig.1.4.Nagpur still dumping 80% mixed garbage in Bhandewadi yard)

### VI. PROPOSED METHODOLOGY

The size distribution of waste constituents in the waste stream is important because of its significance on the selection of appropriate collection, transportation, processing, treatment, and disposal practices. Since latest reliable data on the composition of municipal solid waste management (MSW) is not available for the city of Nagpur, it is proposed to conduct the physical and chemical characterization for MSW. Depending upon the composition of waste, the optimal treatment and disposal technology suitable for the city based on technical, legal, environmental, economic and commercial parameters will be recommended to NMC. The study will involve multi-

stakeholder approach with NMC, NEERI, Regional GIZ Urban Nexus and ICLEI South Asia involved in designing, monitoring and conducting the study.

- The idea of door-to-door (D2D) collection of garbage was not new for Nagpur Municipal Corporation (NMC). This work was started in 1996 in some wards of the city covering about 30% of the total population. But after the Supreme Court directive regarding 100% D2D garbage collection, it was implemented throughout the city.
- Requirements for implementing the directive included equipments like cycle rickshaws, ghanta gadi and manpower.
- In the city of Nagpur there are different types of residential areas like skyscrapers, slums, independent houses, bungalows, government colonies, etc. These categories have been grouped and suitable volunteers have been deployed for garbage collection.
- The volunteers were trained and oriented about waste disposal.
- Every volunteer i.e. ‘Swachata Doot’, cover about 200 – 300 households everyday depending upon the category.
- All the volunteers have been provided with uniforms and safety kit, which includes hand gloves, face mask, cap, etc.
- To oversee project implementation, one supervisor and coordinator has been appointed for every zone.

### VII. CONCLUSION

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.



## REFERENCES

- [1] Nagpur flouting e-waste handling guidelines Apr-3-2013-<https://timesofindia.indiatimes.com>
- [2] Electronic Waste - Maharashtra Pollution Control Board-[www.mpcb.gov.in/ewaste/ewaste.php](http://www.mpcb.gov.in/ewaste/ewaste.php)- Apr-4-2018. 3. Case Study: Integrated Solid Waste Management in Nagpur- Nexus project
- [3] Rohit Sharma E Waste Management Issues Challenges and Proposed Solutions-[www.legalservicesindia.com](http://www.legalservicesindia.com) 5. Mahesh C. Vats and Santosh K. Singh, Status of E-Waste in India - A Review [www.ijrset.com](http://www.ijrset.com) Volume 3, Issue 10, October 2014 retrieved on December 10, 2017
- [4] Office of the Registrar General & Census Commissioner, India. Retrieved 26 March 2012.
- [5] Stamps from the Orange City", The Hindu (Chennai, India). 31 March 2006. Retrieved 19 June 2006.
- [6] Mandal. D. N., Government Of India Ministry Of Water Resources Central Ground WaterBoard, 2009.
- [7] Nagpur. "MSN Green". Retrieved 28 January 2010.
- [8] Modak. P , Nangare. P, "Quantitative And Qualitative Assessment Of Municipal Solid Waste For Nagpur City". Journal of Engineering Research and Studies Vol.II/ Issue II/April-June, E-ISSN0976-7916, 55-61, 2011.
- [9] Sonune M.B. And A.D. Bobdey , "Pollution Studies In Nagpur City With Special Emphasis On The Sources And Possible Control Measures" , Asian Journal Of Contemporary Sciences, Vol.I,ISSN 2319-993, 18-22, 2012.
- [10] Nagpur Municipal Corporation, "City Sanitation Plan", Submitted to Department of Urban
- [11] Development, Govt. of Maharashtra, Mumbai, March 2011
- [12] Garbage dumping in Nag River Continues; NMC fines 100 violators". Times of India May 27,2013
- [13] Dr. Agrawal. V, "Sustainable Waste Management; Case study of Nagpur, INDIA", August 28,2005
- [14] Shirke. A, "Municipal Solid Waste", December, 2009
- [15] Dr. Bhattacharya. A, "Water and Waste Water Management in Power Sector Industries" National Head-Technology; Water and Waste Water Management NPTI Seminar, March 23, 2012
- [16] Nagpur Municipal Corporation, [www.nmcnagpur.gov.in](http://www.nmcnagpur.gov.in)
- [17] Central Railway shows the way on waste water recycling", Times of India, Apr 21, 2013.
- [18] Census Nagpur (2011): Nagpur Population Census 2011 [Online] Available at <http://www.census2011.co.in/census/city/353-nagpur.html>
- [19] CPCB (2016): STATUS REPORT ON MUNICIPAL SOLID WASTE MANAGEMENT [Online] Available at [http://cpcb.nic.in/divisionsofheadoffice/pcp/MSW\\_Report.pdf](http://cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf)
- [20] Hitvada (2016): Nagpur is among top 20 clean cities [Online] Available at <http://thehitavada.com/Encyc/2016/2/16/Nagpur-is-among-top-20-clean-cities.aspx>
- [21] Ministry of Home Affairs (2011a): Census of India. Rural and urban distribution of population. [Online]
- [22] SBU (2016): Swachh Bharat Urban website [Online] Available at <http://www.swachhbharaturban.in/sbm/home/#/SBM>
- [23] Sharma, P. (2014): System to Assess Swachh Bharat Abhiyan Soon, in: The New Indian Express. [Online]. Available at: <http://www.newindianexpress.com/nation/System-to-Assess-Swachh-Bharat-Abhiyan-Soon/2014/10/06/article2464171.ece>
- [24] SWM (2014): Guidelines for Swachh Bharat Mission (SBM) [Online] Available at [http://www.swachhbharaturban.in:8080/sbm/content/writereaddat a/SBM\\_Guideline.pdf](http://www.swachhbharaturban.in:8080/sbm/content/writereaddat a/SBM_Guideline.pdf)
- [25] SWM (2016): Solid Waste Management Rules, 2016- Major changes and likely implications [Online] Available at <http://pibphoto.nic.in/documents/rlink/2016/apr/p20164503.pdf>
- [26] WtE plant (2016): Waste to Energy plants operational in India [Online] Available at <http://www.bestcurrentaffairs.com/waste-energy-plants-operational-india/>
- [27] Solid Waste Management-D Joshep Hangertey, Joseph L. Pavoni,
- [28] Municipal Refuse Disposal – Institute of American Public Health Association, Interstate Printer and Publisher inc-Tanvil Elinoy.
- [29] Solid waste Management in Developing Countries – A.D. Bhide, B.B. Sudresan
- [30]
- [31] Chang, N.B., Pan, Y.C., Huang, S.D., Time series forecasting of solid waste generation, J. Resource. Manag. Technol,
- [32] Grossman, D., Hudson, J.F., Mark, D.H., Waste generation methods for solid waste collection. J. Environ. Eng. ASCE 6,
- [33] Singh, S.K., Singh, R.S., 1998. A study on municipal solid waste and its management practices in Dhanbad–Jharia coalfield. Indian Journal of Environmental
- [34] Quantitative and qualitative assessment of municipal solid waste for Nagpur city Journal of Engineering Research and Studies E-ISSN 0976-7916 Pankaj R.Modak\*, Prakash B. Nangare
- [35] Case Study: Integrated Solid Waste Management in Nagpur- Nexus project.