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A Review Article on "Decentralized Solid Waste Management System in Nagpur City Involving Active Public and NGO Participation"

Mr. Rahul Rajas [1], Prof. Akash Gupta [2], Prof. Rajesh Ingole [3]

PG Student, Department of Civil Engineering, Swaminrayan Siddhanta Institute of Technology, Kalmeshwar, Nagpur, Maharashtra, India[1]

Assistant Professor, Department of Civil Engineering, Swaminrayan Siddhanta Institute of Technology, Kalmeshwar, Nagpur, Maharashtra, India[23]

ABSTRACT- In most Indian cities, the problem of solid waste management is acute. Solid waste management is a critical service for the urban local bodies since many public health issues are connected with it. The situation is particularly bad in the unauthorized settlements and slums in urban areas where municipal solid waste management is virtually absent. Inadequate waste disposal may cause severe environmental and health problems. These problems may be attributed to the partial segregation of recyclable waste, absence of waste collection at source, unavailability of suitable infrastructure to treat and dispose the huge amount of waste generated. In order to meet these challenges, the present paper advocates decentralized solid waste management to minimize the problems of solid waste management in urban areas. The main purpose of the paper is to provide a comprehensive view of the decentralized approach to solid waste management along with the appropriate technologies to solve the problem of processing and treatment of waste.

KEYWORDS: Municipal Solid Waste Management, Decentralized Solid Waste Management, Recycle, Decomposting, Vermi- Composting, Pit Composting

I. INTRODUCTION

Decentralised waste management is about each community managing and processing their waste in their locality and not sending it all to a centralised large processing facility or often land fill. There are two principles behind decentralised waste management: When waste is managed at source it becomes a resource. Decentralized waste management systems, also known as community-level waste management systems, alleviate the strain of managing huge volumes of Municipal Solid Waste at a central place, lowering transportation and intermediate storage expenses.The major undertakings of NGOs in the waste management sector are: Ensuring that people participate in waste segregation, composting organic waste, and recycling waste. Creating mass awareness about the effects of uncontrolled and indiscriminate waste dumping in landfills. Saahas is a Bengaluru-based non-profit organization working in the field of waste management. Since 2001, they have been helping build communities across rural and urban India that manage their waste at source by reducing, reusing and recycling their waste and achieving 90% resource recovery. Any material that is not useful and has lost its economic value in the eyes of its beholder can be termed as waste (WTERT 2011). Although this waste may be a good resource/raw material for many other valuable things. It might be the source of currency/income for others. Like other matter, waste can be distinguished into three types i.e. solid, liquid and gaseous on the basis of physical state. On the basis of the source solid wastes are categorized into municipal wastes, hazardous wastes, medical wastes and radioactive wastes.

Solid waste may include any or all of these components such as garbage, refuse, sludge other discarded material from a water supply treatment plan, domestic, industrial, commercial, mining and agriculture operations and from community activities (James 1997). Although solid waste has been discussed at many forums previously, however people were sensitize by its concept when the World Health Organization (WHO) defined solid waste "as the waste arising out of man's activities which is not free-flowing" in 1971. Cointreau 1982, elaborate the definition of solid waste as "organic

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and inorganic waste materials produced by households, commercial, institutional and industrial activities, which have lost their value in the eyes of the first owner".

India is the second largest country in the world with a population of over 1.21 billion accounting for 17.5 percent of the world population (Census of India, 2011). As per the latest population Census-2011, the urban population grew at a rate of 31.16 percent during the last decade 2001-2011. The increase in population has not only changed the physical size of the cities due to large scale of migration but is also exerting significant additional pressure on the basic services and infrastructure across the Indian cities.

Many Indian cities face the serious problem of solid waste management (SWM) due to rapid urbanization and are struggling to find effective responses to improve the living standard of people. Currently, the Indian cities generates over 1,70,000 metric tons i.e. about 62 million tonnes of municipal solid waste per day. It is assumed that urban India will generate 2,76,342 tonnes per day (TDP) by 2021, 4,50,132 tpd by 2031 and 11,95,000 tpd by 2050 (Plaaning Commission, 2014). The quantity and physical composition of solid waste is continuously changing with population redistribution, changing life styles, income and consumption patterns in Indian cities. While, the share of paper, plastics, rubber, glass and metals is constantly increasing that of the biodegradable organic materials still remains significant in our cities. Out of the total waste generated in India, more than 50 percent waste is organic, 31 percent inert waste and 18 percent is recyclable waste (Earth Engineering Centre, 2012). It is observed that a large part of India's waste is compostable waste. The per capita municipal solid waste generation rate is 200-300 gms/ capita for small towns, 300-400 gms/capita for medium cities and between 400-600 gms/capita for large cities (Planing Commision, 2014).

II. LITERATURE REVIEW

2.1 MUNICIPAL GOVERNANCE AND SOLID WASTE MANAGEMENT

An administrative body having corporate status and the power of self-government or jurisdiction is known as municipality. In India, municipality is often referred as Nagar Palika. Governance means the process of decision making and the process by which decisions are implemented or not implemented. The concept of Municipal Governance in India is being followed since the formation of first Municipal Corporation in Madras in 1687. Lord Ripon, Viceroy of India, got the credit for laying the foundation of democratic form of municipal governance by passing a resolution of local self-government in 1882. The first Government of India act in 1919 was incorporated to formulate the powers of democratically elected government. In 1935, another act was incorporated by the government of India to give specific powers to local government. In 1992, a major step was taken for the empowerment of local governments, with the enactment of 74th Constitutional Amendment Act (Appendix 1).

- Nagar Nigam (Municipal Corporation)
- Nagar Palika (Municipality)
- Nagar Panchayat (Notified Area Council, City Council)

Nagar Nigam (Municipal Corporation):

Nagar Nigam in India works for the development of a metropolitan city, having more than 1 million. It works for providing necessary community services like health centres, education institutes, housing and property tax. The elections for their government are held once in every five year.

Nagar Palika or Municipality:

Nagar Palika is urban local body that works in a city of minimum population of 1, 00,000 but less than 10, 00,000. Elections in Nagar Palika are conducted every five years and the town is divided into wards. The representatives of each ward are elected and the elected members elect a president among themselves to lead the team.

Nagar Panchayat or Notified Area Council or City Council:

Nagar Panchayat is classified urban centre having more than 11,000 and less than 25,000 inhabitants. Nagar Panchayat has committee consisting of a chairman with ward members. Committee of Nagar Panchayat consists of chairman with ward members; with 10 elected ward members and three nominated members.

Municipal Commissioner is appointed as the head of the administrative staff for implementation of the decisions and prepares its annual budget. The newly inserted Twelfth Schedule in 1992 (Article 243W) in the constitution lists the following functions for municipalities:

1. Urban planning including town planning;
2. Regulation of land use and construction of building;
3. Planning for economic and social development;
4. Roads and bridges;
5. Water supply for domestic, industrial and commercial purposes;
6. Public health, sanitation, conservancy and solid waste management;
7. Fire services;
8. Urban forestry, protection of the environment and promotion of ecological aspects;
9. Safeguarding the interest of weaker sections of society, including the handicapped and mentally retarded;
10. Slum improvement and up-gradation;
11. Urban poverty alleviation;
12. Provision of urban amenities and facilities such as parks, gardens, playgrounds;
13. Promotion of cultural, educational and aesthetic aspects;
14. Burials and burial grounds; cremations, cremation grounds and electric crematoriums;
15. Cattle pounds; prevention of cruelty to animals;
16. Vital statistics including registration of births and deaths;
17. Public amenities including street lighting, parking lots, bus stops and public conveniences;
18. Regulation of slaughter houses and tanneries.

Out of these functions, solid waste management is one of the most crucial problems of municipalities. SWM has become one of the important facets of public health. Most of the urban areas are facing lots of problems related to SWM. Municipalities employ large staff on regular and temporary basis to manage solid waste but still solid waste management is not an easy task on day to day basis.

2.2 CONCEPT OF MUNICIPAL SOLID WASTE MANAGEMENT

In past the resources were limited so the goods were repaired and reused. Most of the food and other biodegradable waste were used in agriculture as manure. As the industrialization and urbanization started in early 19th century, problem of solid waste management seems to emerge (NIJKAMP 2001). In the middle of 19th century, several epidemic diseases (like Polio, Epidemic Typhus/Camp fever, Malaria, Cholera, Smallpox, Yellow Fever, Tuberculosis, etc.) infected the cities of Europe and North America. From there the legislations were gradually introduced to address the problem of poor sanitation conditions.

However, during this time the focus of solid waste management remained on waste collection and dumping at the sites far from the human settlement (UN-HABITAT 2010). In 1970s, it was realized that unmanaged solid waste is responsible for water, air and land contamination and has serious impacts on the health. Looking at this scenario World Health Organization recognized solid waste management as a menace problem in 1971 (Liverman et al. 1999). The initial stage focused on phasing out the uncontrolled disposal. Subsequently, the countries of the world started formulating guidelines for controlling the solid waste.

2.3 SOLID WASTE GENERATION AND MANAGEMENT BY FEW MAJOR COUNTRIES OF THE WORLD

USA leads the world in MSW generation among the top10 MSW generating countries includes four developing nation (Brazil, China, India and Mexico) of the world. As such, USA generates about 621,000 tons of MSW per day, followed by China about 521,000 tons per day (Brown 2001).Higher quantities of MSW are being generated by the wealthier regions of the world. Members of the Organisation for Economic Co-operation and Development (OECD), a group of 34 industrialized nations, lead the world in MSW generation, at nearly 1.6 million tons per day. By contrast, sub-Saharan Africa produces less than one eighth, approximately 200,000 tons per day (Worldwatch Institute 2018). Rapid urbanization, increasing industrialization, increase purchasing power and a more sophisticated form of consumerism seems responsible to an increase in the amount and toxicity of waste in middle-income Asian countries (Chaturvedi 2001, 2006; Sharma 1993; Dixit 2015). According to the World Bank, urban areas in Asia generate about 760,000 tons of MSW, or approximately 2.7 million cubic meters per day (Un-Habitat 2010). By 2025 it is assumed

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that this figure will increase to 1.8 million tons of waste per day, or 5.2 million cubic meters of waste (Casanova 2010). Several reports suggest that the intensity of hazardous materials in the waste stream, as well as in recyclable paper, plastic and metal is increased (Hopewell et al. 2009). Thus, densely populated cities of Singapore, Thailand, Malaysia, South Korea, Indonesia, Sri lanka, India and the Philippines are under pressure to modernize their solid waste systems, bring their waste streams under control, and shift from pure disposal to recovery of both energy and materials. Singapore and South Korea are responding to this challenge by testing the usefulness of public–private partnership (PPP) schemes for waste-to-energy plants (Casanova 2010). In 2008, Singapore announced the Keppel Seghers Tuas Waste-toEnergy Plant (KSTP) to be operated under a Design–Build–Own–Operate (DBOO) scheme.
In South Korea, 2008 a similar PPP with Aquentium Inc was implemented and operate a 1000-tonne-per-day waste-to-energy processing plant (Un-Habitat 2010). Malaysia, Philippines, Thailand and Sri Lanka, with somewhat lower Gross Domestic Product (GDP) and a later entry into the modernization process, are making progress in developing regulatory frameworks to institutionalize integrated Solid Waste Management (ISWM), in part to cope with increasing waste challenges due to tourism.

Philippines passed the Ecological Solid Waste Management Act in 2001 and created a National Solid Waste Management Commission to oversee policy implementation nationwide (Un-Habitat 2010). In Thailand, the growing tourism industry is triggering infrastructure improvements in transportation, hotels and ISWM in Bangkok, Chiang Mai, Phuket and other tourist destinations (Un-Habitat 2010). Sanitary landfills and incineration plants have replaced open dumpsites. New recycling centres, such as, the Pobsuk Recycling Centre, are being operated on a pilot scale.

The World Bank's Metropolitan Environmental Improvement Programme (MEIP) is credited for solid waste management improvements in large cities in Asia, such as Beijing, Bombay, Colombo, Jakarta, Metro Manila and Kathmandu (Saran 1997, 2001; Gilbert et al. 2013). Between 1994 to 1998, the South-East Asia Local Solid Waste Improvement Project (SEALSWIP), a Canadian International Development Agency (CIDA) assistance programme, successfully assisted communities in the Philippines, Thailand and Indonesia in various aspects of SWM, including organizing waste-pickers and junk shops; setting up a 'waste bank' for recyclables; siting landfills; and providing training on hazardous waste management (Un-Habitat 2010). From 1996 to 2001, the Sustainable Cities Programme, a joint programme of UN-Habitat and the United Nations Environment Programme (UNEP), assisted cities in China, India, Sri Lanka, the Philippines and Indonesia to set up solid waste management systems. In 2002, UNEP and its International Environmental Technology Centre (IETC) organized an Association of Southeast Asian Nations (ASEAN) High-Level Consultation (HLC) Group to establish a policy level forum to deal with solid waste issues. The HLC heightened awareness on the urgency of the problem in the region and encouraged the pursuit of national initiatives in SWM. One decade back initiative in ISWM in Asia is the Regional 3Rs (reduce, reuse, and recycle) forum financed by the Japanese Environmental Ministry, and organized in 2008 by the Institute for Global Environmental Strategies (IGES), a research and development (R&D) institution in Japan. It involves governments, donor agencies and scientific institutes of 12 Asian countries. With support from the Japanese government, it aims to promote policy development and projects on the 3Rs. The World Bank is especially, perceived to be effective in introducing the concept of the 3Rs, materials recovery and sanitary landfills. CIDA was found to be effective in community organizing for waste collection and recycling, while the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) gets some credit for introducing sanitary landfills to some countries in South-East Asia.

2.4 SOLID WASTE MANAGEMENT IN INDIA

The urbanization in India has grown five folds in last six decades with 377 million people living in urban area (Census 2011). Over the years, there has been a continuous migration of people from rural and semi-urban areas to towns and cities (Samwal 2015; Khosal and Semwal 2011; Semwal and Khosal 2009; Sukla 2001). The proportion of population residing in urban areas has increased from 10.84% in 1901 to 25.70% in 1991. The uncontrolled growth in urban areas has left many Indian cities deficient in infrastructural services such as water supply, sewerage and municipal solid waste management. This urban population generates thousands of tons of MSW which is further expected to increase significantly (Joshi and Ahmed 2016).

SWM seems to be one of the neglected activities in India. The management of MSW is becoming increasingly expensive and complex due to the continuous and unplanned growth of urban centres. The difficulties in providing the desired level of public service in the urban centers are often attributed to the poor financial status of the managing municipal corporations (Gupta 1998; Ahsan 1999; MoEF 2000; Raje et al. 2001; Mor et al. 2006; Siddiqui et al. 2006; Gupta 2010).

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[1] Refuse Derived Fuel to Electricity (2013)

If we focused on solid waste management (SWM) the waste produced was collected and dump in dump yard which causes many environmental pollutions and health hazards. In solid waste management land filling is a major problem. Many difficulties arise while extending the land for land filling. In order to overcome those problems Refuse-Derived Fuel (RDF) is one of the best options. Refuse-Derive Fuel is obtained from municipal waste and it is one of the alternative fuels. It is the process of converting waste into useful energy. By doing so the problem with solid waste management get reduces and RDF can be substituted for coal in boilers. This paper deals about the manufacturing and application of RDF in India.

[2] Assessment of Municipal Solid Waste Management in Kochi City (2021)

Considering the case of Kochi City (Ernakulam, Kerala), Solid waste management is a major issue. Improper Management of MSW (Municipal Solid Waste) leads to air, water and soil pollution. Kochi City have been facing issues related to the collection, treatment and management of solid waste. Therefore, there is an urgent need for an improved planning and implementation of comprehensive solid waste management system for upgrading the environmental scenario of the city. For proposing an Integrated Solid Waste Management system in the city, primary and secondary data were collected. Also physical and chemical analysis of the waste, population forecasting of Kochi city were conducted. All the main problems related to the waste management are identified. Assessing the main problems and considering all the alternatives, recommendations in each stage for the MSWM are suggested. This paper suggests an integrated municipal solid waste management plan for Cochin City. Future studies should be carried out for checking the efficiency of the proposed methods. This study introduces various alternatives for the MSWM. The most economical and viable methods can be used for treating the waste from the city. The physical and chemical characterization of the waste indicates that the wastes are rich in biodegradables and plastics. The population forecasting details show that the waste produced in the future years are much higher and it keeps on increasing. Through the combined efforts of individuals from household and a proper MSWM system, Kochi city will be able to dispose waste generated and in future, piling up of legacy waste can be avoided.

[3] Solid Waste Management: A Case Study of Nagpur City (2022)

The objective of this paper is to examine the waste management of Nagpur city. Nagpur is one of the largest market place in India with population of 24, 05, 665 NMC has divided Nagpur in total of 10 zones for proper administration. Due to factors like industrialization and urbanisation it is the fastest growing city leading to increase in waste generation. This present case study aims to analyse current MSW management practices and its status and it also discusses the issues related with collection, transportation, treatment and disposal. The goal of this study is to help in minimizing the waste generation and to reduce its impact on humans. It also suggests ways to improve the administration of NMC. It is discovered From December fifteen to thirty one of the year 2021, the town generated over 21,100MT garbage. Out of this, around 12,700MT mixed garbage has been transported and droped at Bhandewadi. This means, around 55% people are still handing over the mixed garbage to non-public agencies engaged in door-to-door trash collection. The NMC has not been able to accomplish the goal of stopping waste merchandising in Bhandewadi. Atomic number 47 surroundings has collected 10,459,41MT garbage from Laxmi Nagar, Dharampeth, Hanuman Nagar, Dhantoli andstatesman Nagar zones. Rather than lifting solely divided garbage, it transported largely 6,067. 09MT mixed garbage. BVG India, that provides services in Gandhibagh, Satranjipura, Lakadganj, Ashi Nagar and Mangalwari zones, collected 6,635.16MT mixed garbage out of totalten,689.02MT. Of the 1,567 trips, it created 978 journeys with mixed garbage that is discarded at Bhandewadi.

[4] Waste to Energy Solution in Antiquity and Ibadan (2014)

Waste to energy solution, the technology that converts municipal solid waste to energy has been discussed by several ancient and modern scholars. Several other authors have identified the types of waste as well as energy derived from such wastes, the various types of processes and the consequences of waste to energy technology in some other countries. This study examines waste to energy solution in antiquity, and proposes a modern equivalence for the sprawling metropolis of Ibadan. The paper further argues that turning waste to energy has environmental and health implications for the society.

The argument being put forward in this discourse is that since ancient Greeks and Romans could take recourse to renewable energy, albeit in a rudimentary manner devoid of modern technology, it is therefore pertinent that this technology, which has become modern, be adopted to address the waste problem of Ibadan, and provide renewable energy from waste for the city. Further studies may examine how the technology can be adopted and simplified for individual personal structures, and other parts of the country. The idea of converting waste to energy may have been borne out of man's desire to move from one stage of development to another. This stage is to discover and invent

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methods to solve the problem of air pollution that cause diseases as a result of accumulated and decomposing waste. Therefore the theory of social development explains this phenomenon.

[5] Energy Efficient Refuse Derived Fuel (RDF) From Municipal Solid Waste Rejects: A Case For Coimbatore (2014)

In this paper production of energy efficient Refuse Derived Fuel (RDF) from municipal solid waste rejects was carried out during August 2012 – April 2013 in Coimbatore City India. Municipal Solid wastes rejects (paper, plastics with exception of polyvinyl chloride, textiles) were collected from waste dump yard of Coimbatore City. Sawdust, coir dust, water hyacinth and rice husk were mixed with the collected wastes at a fixed amount of 20 percent. After grinding, cassava starch was used as a binder to produce RDF briquettes with the help of uniaxial piston briquettes making machine. Physical, chemical and thermal characteristics of the RDF were studied to assess their potential use as energy efficient material. The analyses were divided into three categories namely, physical, proximate and ultimate analyses. Results indicated that, under physical and proximate analyses; impact resistance index (IRI) for all the RDF samples were 200, density were less than 1 kg cm3, moisture were less than 10 % wt, ash content varied from 2.8 to 9.2 % wt, whilst volatile mater had mean value of 83.1 % wt and fixed carbon which is by subtraction ranged from 1.4 to 9.2 % wt. With respect to Ultimate analysis, Oxygen, carbon, hydrogen varied from 27.01 to 39.78 % wt, 44.8 to59.7 % wt, 5.9 to 8.1 % wt respectively. On the other hand nitrogen, sulfur and chlorine ranged from 0.18 to 0.87 % wt, 0.27 to 0.71 % wt and 0.339 to0.521 % wt respectively. Calorific values (high heating values) ranged from 5085 to 6474.9 kcal kg-1. The results were compared with Energy research Centre for the Netherland database and noted that with exception to moisture, fixed carbon and hydrogen other parameters had a significant lower or higher differences. From the study, RDF from municipal solid wastes rejects along with the additives produced high energy efficient materials. Keywords: Municipal Solid Waste, Waste to Energy, RDF, Calorific value.

2.4.1 Nature and quantification of solid waste in India

Solid waste include large countless different materials like food waste, paper, plastics, metals, glass, discarded cloths, accessories, garden waste, radioactive waste and other hazardous waste. Indian MSW compositions vary greatly with regards to composition and nature when compared to MSW of western countries (Jalan and Srivastava 1995; Shannigrahi et al. 1997; Gupta et al. 1998). The physical characteristics of MSW in metrocities are presented in Table 2.2. MSW is in compostable materials (40–60%) and inerts (30–50%). Per capita waste generation ranges between 0.2 kg and 0.6 kg per day in the Indian cities amounting to about 1.15 lakh MT of waste per day and 42 million MT annually (CPCB 2000). According to Planning Commission Report 2014, 377 million people residing in urban area generate 62 million tons of MSW per annum currently and it is projected that by 2031 these urban centres will generate 165 million tons of waste annually and by 2050 it could reach 436 million tons.

2.5 DISPOSAL SYSTEM OF WASTE IN INDIA

India is known for adopting unscientific disposal of MSW. The studies revealed that an uncontrolled open dumping is a common feature in many cities. Women has always played a crucial role in the disposal of waste in India (Shukla and Shukla 1996; Sharma 2002; Kumar et al. 2009; Gairola 2011). The most commonly used mechanism of waste disposal adopted in India is composting (aerobic composting and vermi-composting) and waste-to-energy (WTE) (incineration, pelletisation, biomethanation). WTE projects for disposal of MSW are a relatively new concept in India (Sharholy et al. 2008).

Recently it has been observed that some of the cities are stepping forward rapidly and managing their solid waste in an effective way. Sensitized people of certain cities like Delhi NCR, Ahmadabad have managed their waste in an efficient and effective way (CPCB 2013).

2.5.1 Segregation

In India, organised or scientifically segregation of MSW either at household level or at community bin is poorly observed. Waste is segregated and sorted under unmanaged conditions. The segregation effectiveness is also very low and only valuable constituents from the waste are separated (Kaushal et al. 2012). Due to improper handling the segregated constituents got mixed up again during transportation and disposal (CPCB 2013). This lack of segregation deprive proper scientific disposal of waste (Singhal and Pandey 2000).

2.5.2 Collection of solid waste

The collection of solid waste in India is carried out by municipalities/corporations. The most common system of collection of waste through communal bins placed at different points in the cities. They serve as the primary storage centre in the cities. In some cities the contracts are given to the private operators for doorsteps collection however these

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efforts of door to door collection are in preliminary phase. The sweeper after sweeping the road put the waste into a wheelbarrow and transfer waste to dustbins or collection points (Kansal et al. 1998; Bhide and Shekdar 1998; Malviya et al. 2002; Nema 2004; Colon and Fawcett 2006). From this it is transferred to disposal sites. Mumbai (Maharashtra) and Ludhiana (Punjab) have 100% waste disposal, in Delhi and Surat (Gujarat) around 95% of MSW reached its landfill sites, and in the rest of the cities/town less than 90% waste reached dumpsites (FICCI 2009; CPCB 2013).

However more comprehensive details suggests the collection efficiency in most of the Indian cities is poor and is about only 70% (Khan 1994; Maudgal 1995; Gupta et al. 1998; Nema 2004; Rathi 2006; Siddiqui et al. 2006). During the year 2011, about 1, 27,486 TPD MSW was generated in the country, out of which only 89,334 TPD (i.e. 70%) was collected and 15,881 TPD (i.e. 12.45%) processed or treated (CPCB 2013). During the last decade, solid waste generation has increased 2.44 times (ibid).

2.5.3 Transfer of solid waste

From the collection points the waste is transported to the disposal or processing sites by the variety of the vehicles. In smaller towns bullock carts, tractor- trailers etc. are used while in big towns light motor vehicles are used. These vehicles generally have open uncovered body without a lid and the waste spills onto the roads. It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per ton on solid waste for collection, transportation, treatment and disposal (Department of Economic affairs Ministry of Finance Government of India 2009). About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste (Lokeshwari and Swamy 2012).

2.5.4 Open dumping and land filling

The dumping of MSW on low lying area violating the sanitary landfilling is the most common practice. Almost no city in India has 100% adequate sanitary landfilling facility. The waste is dumped at the outskirts of the town along the roads. This open dumping creates serious health issues. Such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters. In larger towns or cities like Delhi, the availability of land for waste disposal is very limited (Khan 1994; Chakrabarty et al. 1995; Gupta et al. 1998; Das et al. 1998; Kansal et al. 1998; Mor et al. 2006; Siddiqui et al. 2006; Sharholy et al. 2006). Sanitary landfilling is an accepted and recommended way for proper disposal of MSW. However, there is the requirement of certain improvements to ensure sanitary landfilling (Dayal 1994; Das et al. 1998; Kansal 2002).

2.6 Treatment of the organic waste

The MSW in India comprises of 50-65 % of biodegradable matter which are processed in number of ways (Kumar and Pandit 2013). Some of the following techniques used for processing of organic waste are as follows:

(a) Composting:

Compositing is the biodegradation of organic matter by biological agents to produce manure. There are several advantages of this method like minimization of the gases, harmful pathogens are killed and foul smell is eliminated. The final end product is compost or humus. This humus is used as fertilizer (Khan 1994; Ahsan 1999). Compositing includes anaerobic (in absence of air), aerobic (in the presence of air) and vermicomposting (using earthworms). Composting is known in India since the time immemorial. The MSW (Management and Handling) Rules 2000 (MSW Rules 2000) have specified certain limits to acceptable percentage of heavy metals in compost produced from MSW and a mechanism is put in place to ensure that the same are strictly implemented.

(b) Incineration:

It is the method of volume reduction of refuse. The method is mostly followed in developed countries and is mostly suitable for the waste with high calorific value waste having a large component of paper, plastic, packaging material, pathological wastes, etc. It can reduce waste volumes by over 90 percent and convert waste to innocuous material, with energy recovery. In Indian cities incineration is not very much practiced. Because MSW of Indian cities have low calorific value content and high organic material (40–60%), high moisture content (40–60%) and high inert content (30–50%) (Jalan and Srivastava 1995; Chakrabarty et al.1995; Sudhire et al. 1996; Bhide and Shekdar 1998; Joardar 2000; Kansal 2002). An incinerator was installed at Timarpur, Delhi in the year 1987 which has 3.75 municipal waste power generating capability from 300 TPD MSW. It could not operate successfully due to low net calorific value of MSW.

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(c) Gasification technology:
Incineration of solid waste under oxygen deficient conditions is called gasification. The first unit in India (NERIFIER gasification unit) is installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) for the burning of agrowastes, sawmill dust, and forest wastes. The second unit is the TERI gasification unit installed at Gaul Pahari campus, New Delhi by Tata Energy Research Institute (TERI) (Ahsan 1999; CPCB 2004).

(d) Pyrolysis:
This process involves the destructive distillation of homogenous organic matter in the waste in a closed vessel without oxygen. Toxic materials get encapsulated in vitreous mass, which is relatively much safer to handle than incinerator/gasifier ash. No commercial plant has come up in India or elsewhere for the disposal of MSW. It is an emerging technology for solid waste, yet to be successfully demonstrated for large-scale application.

(e) Treatment of non-degradable waste:
Burning of non-degradable waste is a common practice across the globe. Recently France has come up with the technology which can convert non-degradable waste into energy. This technology will be helpful to keep the environment clean.

2.7 POLICY AND LEGISLATION FRAMEWORK FOR MUNICIPAL SOLID WASTE MANAGEMENT IN INDIA

The history of MSW management in India can be traced back to the Five Year Plan of (1969-74) to establish better facilities for MSWM. The funds have been provided to state governments to set up MSW composting facilities. Later, in 1975, The Government of India appointed a high-level committee to review the problem of urban solid waste in India. This committee made 76 recommendations covering 8 important areas of waste management. In 1975-1980, under the National Scheme of Solid Waste Disposal, 10 mechanical composting plants with processing capacities ranging from 150 to 300 tonnes of MSW per day, were set up in several Indian cities with populations over 300,000 (Hoornweg and Laura 1999). In 1990, the National Waste Management Council was constituted by the Ministry of Environment and Forests and one of its objectives was municipal solid waste management (UNEP 2011). In 1993, National Waste Management Council constituted a national plastic waste management task force to suggest measures to minimize the adverse environmental and health impacts arising out of plastic recycling. Based on the recommendations of this task force, in 1998 the Ministry of Environment and Forest came out with draft Recycled Plastic Usage Rules 1998, which bans storing, carrying and packing of food items in recycled plastic bags and specifies quality standards for manufacturing recycled plastic bags.

The outbreak of an epidemic in Surat in 1994 served as an alarm for the Government of India and residents of the country as it reflected the magnitude of impacts of improper urban solid waste management (Talyan et al. 2008). Consequently, in 1995, a high powered committee (Bajaj committee) was constituted to review urban solid waste management. This committee gave a number of suggestions including the need for source segregation, community based door-to-door collection and transportation, charging user-fees, standardization of the design of municipal vehicles for transportation, the need for composting of waste and use of appropriate technologies for waste treatment and disposal.

In January 1998, another expert committee (Asim Burman Committee) was formed under the Honourable Supreme Court of India to identify deficiencies and make recommendations to improve solid waste management in Class I cities (Dube 1982). After reviewing all aspects of solid waste management, the committee submitted its detailed recommendations in 1999. To ensure compliance, the principal recommendations of these committees have been incorporated in the MSW (Management and Handling) Rules 2000 notified by the Ministry of Environment and Forest in 2000.

According to MSW (Management and Handling) Rules 2000, local municipal bodies are responsible for the implementation of the provisions of these rules, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of MSW.
The rules mandate that biodegradable waste be processed by adopting an appropriate combination of processing systems (composting, vermin- composting, anaerobic digestion, pellatisation, etc.) and land-filling be restricted to only non-biodegradable, inert waste and other appropriately stabilized biological waste. These rules mandated all cities to set up appropriate waste treatment and processing facilities by 2003 (Asnani 2006). In 2000, a comprehensive manual on MSW Management was published by the Central Public Health Environmental Engineering Organisation under the

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Ministry of Urban Development for the guidance of urban local bodies to implement the MSW (Management and Handling) Rules 2000. The MSW (Management and Handling) Rules 2000 had been amended from time to time with latest in 2017.

2.7.1 Honourable Supreme Court of India recommendations

In recent years, the current SWM system in India has got considerable attention from the Central and State Governments and local municipalities. The first initiative was taken by the Honourable Supreme Court of India in 1998, which resulted in formation of a Committee to study the current status of SWM in Indian cities. This committee identified the deficiencies/gaps in the existing SWM system in the country and prepared the Interim Report on SWM Practices in Class I cities. Class I cities are cities with a population ranging between one lakh to ten lakhs (1, 00,000 to 10, 00,000). The committee made recommendations pertaining to MSW design criteria.

2.7.2 Municipal solid waste management rules

As a second initiative, the Ministry of Environment and Forests (MoEF), Government of India, published "Municipal Solid Waste (Management and Handling) Rules 2000" (MSW Rules 2000). These rules were developed in conformance with Sections 3, 6 and 25 of the Environment Protection Act, 1986 and amendment 74th, article 243W of the Indian constitution aims at standardization and enforcement of SWM practices in the urban sectors. These rules dictate that "Every municipal authority shall, within the territorial area of the municipality, be responsible for the implementation of the provisions of these rules and infrastructure development for collection, storage segregation, transportation processing and disposal of municipal solid wastes". In addition, "the CPCB shall coordinate with State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) in the matters of MSW disposal and its management and handling".

Concerned by the seriousness of continuing pollution of the environment, the Ministry of Environment and Forests, GoI has issued a Notification in the official Gazette (Gairola and Singh 2014). The impact of enlarged facilities needs to be assessed and Environmental Clearance from the MoEF has to be obtained. According to the notification number SO1533 dated 14th September 2006, the development of Sanitary Landfill Facility projects fall under 7 (I) of the schedule specifying list of projects and activities requiring prior Environmental Clearance under Category B and require clearance from the Expert Committee of MoEF dealing with Common Municipal Solid Waste Management Facility (CMSWMF).

2.7.3 Clean India Mission

Clean India Mission or Swachh Bharat Abhiyan is a national campaign launched by the Prime Minister of India, Narendra Modi from Raghat, New Delhi on 2nd October 2014. The main objective of this campaign was to eliminate the open defecation by the construction of 90 million toilets in rural India at the projected cost of ₹1.96 lakh crore. The programme aims to involve the Indian citizen to clean the country.

It covers 4041 statutory towns across India and with the aim to clean streets, roads and infrastructure by October 2, 2019 (Mahatma Gandhi 150th birth anniversary). Major component of the campaign are:

a) Construction of individual sanitary latrines for households below the poverty line with subsidy (80 percent)
b) Conversion of dry latrines into low-cost sanitary latrines
c) Construction of exclusive village sanitary complexes for women providing facilities for hand pumping, bathing, sanitation and washing on a selective basis.
d) Setting up of sanitary marts
e) Total sanitation of villages through the construction of drains, soakage pits, solid and liquid waste disposal
f) Intensive campaign for awareness generation and health education

2.8 SITUATION OF SOLID WASTE MANAGEMENT IN NAGPUR

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.

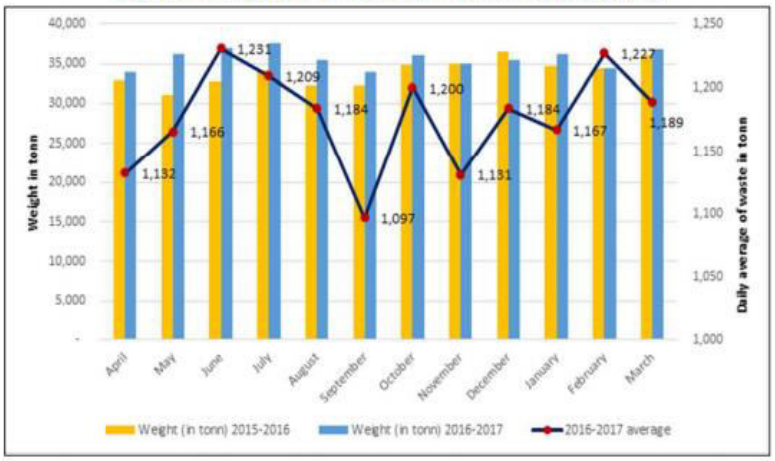
Based on the available weighbridge record, approximately 14,000 tonnes of waste reached the dumpsite in 2016 –17 (April-March), and 13,300 tonnes in 2015-16 (April-March). The average daily collection of waste based on the weighbridge record for last two years is 1,119 tonnes per day. Figure 4-1 and Table 4-1 show the details on the average monthly waste received at the Bhandewadi weighbridge and provides details on the average waste generated per day in the different months of 2016-17.

Table 4-1: Municipal Solid Waste dumped at Bhandewadi dumpsite, Nagpur during April 2015 to March 2017

Sl. No	Year	Waste Dumped per month (in tonne)	Average Daily (in tonne)
1	Apr-15	32,907	1,097
2	May-15	31,103	1,003
3	Jun-15	32,785	1,093
4	Jul-15	34,164	1,102
5	Aug-15	32,330	1,043
6	Sep-15	32,255	1,075
7	Oct-15	34,785	1,122
8	Nov-15	34,986	1,166
9	Dec-15	36,448	1,176
10	Jan-16	34,738	1,121
11	Feb-16	34,443	1,188
12	Mar-16	36,080	1,164
13	Apr-16	33,970	1,132
14	May-16	36,140	1,166
15	Jun-16	36,923	1,231
16	Jul-16	37,483	1,209
17	Aug-16	35,511	1,146
18	Sep-16	33,999	1,133
19	Oct-16	36,007	1,162
20	Nov-16	35,068	1,169
21	Dec-16	35,517	1,146
22	Jan-17	36,181	1,167
23	Feb-17	34,349	1,227
24	Mar-17	36,848	1,189

(Source: Data from Weighbridge at Bhandewadi for the years 2015-16 and 2016-17, Nagpur Municipal Corporation)

Figure 4-1: Incoming Waste to Weighbridge at Bhandewadi Dumping Site



Source: Based on the data collected from Bhandewadi Weighbridge Nagpur from April 2015 – March 2017

(Source: Based on the data collected from Bhandewadi Weighbridge Nagpur from April 2015 – March 2017)

Photo 4-1: Vehicles weighing and maintenance of waste record at Bhandewadi weighbridge

Photo 4-2: Dumper Placer at Weighbridge

Photo 4-3: Dump Truck at Weighbridge

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.

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.

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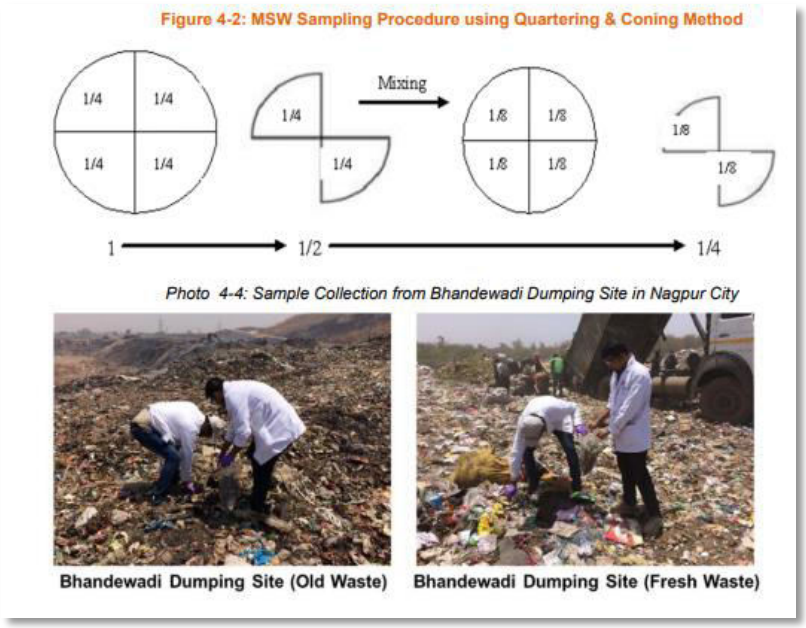
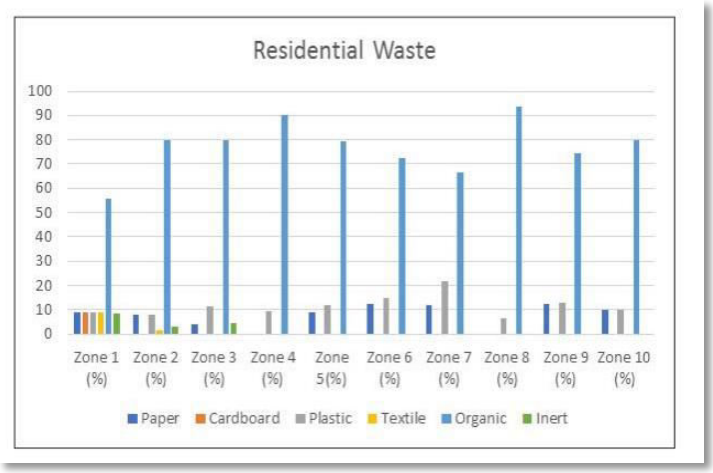


Waste composition from the dumpsite is shows approximately 40 % of organics, followed by plastic (18%) and paper (11%).The organic content at the dumpsite is slightly lesser than the composition of waste collected from the residential area, institutional & commercial areas due to mixing of street sweeping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



(Figure 4-3: Physical Characteristics of Waste Collected from Zones)

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

III. 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.The preceding discussion thus concludes that the solid waste management is a critical issue in India. Most of the challenges of the solid waste management and environmental sustainability are still unanswered. The condition is even worse for the unauthorized settlements and slums in urban areas where municipal solid waste management is virtually absent. It is pertinent to note that the improvement in the solid waste management is the greatest challenge being faced by the municipal authorities. The decentralized approach could be one of the effective methods to solve the problems of waste management in India as it has potential to reduce the quantity of waste by changing the mindset of the people and reduces the transportation cost, reduces the traffic congestion, reduces the amount of air pollution, road maintenance cost, and contamination of ground water through the seepage of leachates. More important, it reduces the amount of waste in landfill sites as the land is a major constraint of the solid waste management system. Finding new landfill sites around cities is nearly impossible because of various constraints like lack of space for locally unwanted land uses, population density and the scale of India's increasing urban sprawl. Decentralized approach is not only sustainable and financially viable but also helps to improve the quality of life and working condition of the waste pickers. It could bring about citizen participation, and contribute to environmental sustainability and economic efficiency.

An analysis of various technological options indicates that due to lack of segregation of waste at source, the recycled products are mostly of poor quality and low cost, incapable of finding markets occupied by virgin materials based products. As a result, both the people involved in the trade as well as the products produced from recycled waste are a largely neglected a lot. In addition, the recycling industries face a number of problems such as (i) reuse and recycling of waste is labour oriented and inadequate, (ii) the processing of waste by small scale industries is not compliance with regulatory requirements. Also, there is no policy for recyclable products. Compost is rarely financially competitive to heavily subsidized chemical fertilizers and traditional cow dung or poultry manure. Therefore, there are fewer buyers

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available in the market for the compost. The market for compost is still underdeveloped despite its potential. The analysis further indicates that no technology is perfect. All of them have advantages and disadvantages as well.

In order to overcome the above cited problems of solid waste management, community based decentralized solid waste management should be promoted with the community participation but with municipal support. In this regard, the policy paper or action plan should be prepared to promote the community based decentralized waste management system. Zero waste approach should be introduced to minimize the waste and change the consumption habits of people. Government should prepare the plan for recycling products which encompasses the quality of products, guidelines to the recycling industries including the compliance with regulatory requirements and marketing policy for recycled materials and compost.

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