IJARASEM

ISSN: 2395-7852

International Journal of Advanced Research in Arts, Science, Engineering & Management

Volume 10, Issue 3, May 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 6.551

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 3, May 2023 |

Decentralized Solid Waste Management System in Nagpur City Involving Active Public and NGO Participation

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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

1.1 BACKGROUND OF THE STUDY

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 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).

1.2 TYPES OF WASTE

Solid waste is classified mainly into five different types depending on its nature as shown in table 1.1

Table 1.1: Types of Waste

S.No.	Types of Waste	Definition
1.	Municipal solid waste	Waste generated from residential and commercial premises in the municipal or notified area.
2.	Industrial waste	Waste material produced during an industrial activity. This type of waste can be either hazardous or non-hazardous in nature.
3.	E-waste	It refers to the disposal of broken or obsolete electronic components and materials.
4.	Plastic waste	Waste generated from indiscriminate use and disposal of plastic into the physical environment.
5.	Biomedical waste	Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological.

1.3 MUNICIPLA SOLID WASTE

Table 1.2: Municipal solid waste on the basis of Source of generation

Sources	Typical waste generators	Types of solid waste
Residential	Single and multifamily Dwellings	Food wastes, paper, cardboard, plastics, textiles, glass, metals, ashes, special wastes (bulky items, consumer electronics, batteries, oil, tires) and household hazardous wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, government center, hospitals, prisons	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Municipal Services	Street cleaning, landscaping, parks, beaches, recreational areas	Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other

The exact estimate of MSW generated in the world seems ambiguous however some estimates shows that nearly 1.7–1.9 billion metric tons of MSW is generate per year (UNEP 2011). Also, due to this MSW about 2.5 billion people worldwide don't have adequate sanitation (Karija et al. 2013). The MSW production is expected to double in the next 15 years i.e. 1.3 billion tons a year in 2010 to 2.2 billion tonnes a year in 2025 (Hoornweg and Bhada-Tata 2012). The main reason for this increase is attributed to urbanisation, modernisation and developmental activities. Reports confirms that the cost of management of this MSW is increasing and it may reach about $375.5 billion in 2025 (Hoornweg and Bhada-Tata 2012).

Solid waste disposal and wastewater are significant sources of methane (CH_4). They are estimated to contribute to about one-fifth of global anthropogenic methane emissions (EPA 2006). Methane is one of the major constituent of the greenhouse gasses and, is responsible for the global warming. Some estimates projects that the world's waste production could reach up to 27 billion tonnes by 2050 (Karak et al. 2012); that will further correspond to increase in methane emission.

Due to the socio-economic differences the conditions, issues, problems and composition of MSW in the developed and developing countries are somewhat different from each other. Reports confirm that the developed countries are generating a large amount of waste despite the availability of well adequate facilities, competent government institutions and bureaucracies to manage their wastes (Hodges et al. 2011). On the other hand, the waste quantity in the developing countries is increasing rapidly but they currently have an insufficient collection and improper disposal of waste (Rajput et al. 2009). The typical problems are low and irregular collection services, open dumping and unscientific disposal mechanism (Bartone 1995). As per the records, one to two-thirds of the MSW generated in the cities of the developing countries is not collected (World Resources Institute 1996). As a result, the uncollected waste, which is often also mixed with human and animal excreta, is dumped indiscriminately along the streets and in drains and contributes to flooding, breeding of insect and rodent vectors and the spread of a large number of diseases (Cointreau 1982; UNEP-IETC 1996; Zurbrugg 2002). The indiscriminate open dumping of MSW in water bodies' sources and low lying areas without consideration of its effect on the environment and human health is a common practice in many cities of the developing countries (ISWA and UNEP 2002; Zurbrugg 2003; Da Zhu et al. 2008; Medina 2010).

Economic prosperity contributes to the higher percentage of the urban population which ultimately leads to the larger production of solid waste (Hoornweg and Laura 1999). The MSW in India is expected to increase significantly in the near future as the country is expected to attain an industrialized nation status by the year 2020 (Shekdar et al. 1992; CPCB 2004; Sharma and Shah 2005). The collection efficiency of solid waste in the major metro cities is between 70 to 90% whereas in several smaller cities it is below 50% (CPHEEO 2000). Despite the degradation of valuable land resources and creation of longterm environmental and human health problems, uncontrolled open dumping is still prevalent in most cities and towns of developing countries including India (ISWA and UNEP 2002). Poor collection and inadequate transportation are the main reason for the accumulation of MSW in the every small to big cities and towns of the country. The management of the MSW is in the critical phases which desperately need an immediate and concrete action in this regard. The physical and chemical composition of the MSW in India had shown the significant relations with the population density and socio-economic status (Sharholy et al. 2007).

MSW management is an integral part of public health and sanitation. But due to lack of awareness, most of the MSW remains unattended. The percentage of community sensitization and public awareness is very low in India. So, people's perceptions and participation in planning and decision making process to better MSW management is the need of the hour. It is not only important to involve individuals but there is an equally essential requirement for the involvement of private sectors, NGOs and other organization to manage this problem efficiently along with the municipality.

Municipal waste management in India has become an area of concern due to population growth, growing economy activities, industrialization and use of expansive modern technologies. The gravity of the situation is such that it is has led to a series of cities crumbling under the pile of garbage. Hence, the need of the hour is to take concrete steps in order to counter this problem. According to PwC-ASSOCHAM Report, 2017.

- India which is the second most populous nation in the world comprises of 17.86 percent of the world's most populous country by 2022.
- About 32.8 percent of its population is urban and with the urban population increasing at 3-3.5 percent per annum, the per capita waste generation is increasing by 1.3 percent per annum.
- At the present rate, waste generation is projected to increase from 62 million tons per year to about 165 million tons in 2030.
- According to the data from the Ministry of Environment, Forest, and Climate Change, the Government of India, only about 75 to 80 percent of the municipal waste gets collected and only 22 to 28 percent of this waste is processed and treated.

1.4 DECENTRALIZED SOILD WASTE MANAGEMENT

The Decentralized Solid Waste Management (DSWM) is a system to provide a clean environment and hygienic living condition by reducing the quantity of waste at source. It involves the management of municipal solid waste by various small waste management centres within the locality. Such centres are called Integrated Resource Recovery Centres (IRRC) which can be either profit making or notfor-profit organizations engaged in collecting, transporting and processing around 2 to 20 metric tons of waste from the locality (Karthykeyan et al., 2012). The decentralized system is not only sustainable and financially viable but also helps to improve the quality of life and working conditions of the waste pickers. Decentralized or at source segregation and treatment of waste has become the most practical and acceptable solution to the menace of garbage. Many bulk waste generators such as large industries, hotels, IT companies and some forward looking municipal corporations have started adopting various decentralized waste

| ISSN: 2395-7852 | www.ijarasem.com | Impact Factor: 6.551 |Bimonthly, Peer Reviewed & Referred Journal|

| Volume 10, Issue 3, May 2023 |

management solutions as a part of their overall waste management strategies. Decentralized organic Solid Waste (SW) composting promotes green growth, reduces GHG emissions and also reduces transportation of organic SW to waste disposal site. In order to encourage innovation and adoption of decentralized waste recycling solutions, government may consider fiscal and financial incentives for setting up and operation of 'Garbage to Garden' and 'Garbage to Gas' decentralized models with waste generating communities' engagement (The Economic Times, 23rd October 2013, p10). The Municipal Solid Wastes (Management and Handling) Rules 2000 provides legal support to the community based waste management. According to the Rules, the ULBs should promote and implement the waste segregation at source. Compliance with these Rules requires that ULBs set up an appropriate systems and infrastructure facilities for undertaking scientific collection, transportation, processing and disposal of SW. However, ULBs to manage solid waste in the city has defeated the goal of MSWM Rules. Systematic weaknesses at the ULB level exist due to resource, capacity and financial constraints and these have resulted in poor collection, transportation, treatment and safe disposal of solid waste.

Another initiative is observed from Purdilpur ward of Gorakhpur where the Gorakhpur Environmental Action Group in collaboration with M.G. Post Graduate College, Gorakhpur has taken up pilot initiative towards community based solid waste management in Purdilpur ward. This initiative is supported by Rockefeller Foundation under the Asian Cities Climate Change Resilience Network (ACCCRN). The initiative was to comply with MSW handling rules 2000 in decentralized way through participation of the community to bring sustainability to solid waste management in the city. Initially 120 households of Purdilpur ward responded positively, but later, the number has gone up to 200 households. This initiative aims at setting up a model of solid waste management before the local government and creates awareness among the community towards community based solid waste management.

- Solid waste management alone by municipalities in Nainital district is unmanageable.
- The population and urbanization in the district is increasing so the solid waste is also expected to increase.
- The problem of solid waste management cannot be solved without the people's participation.

II. Situation of solid waste management in Nagpur

Waste Quantification-

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)

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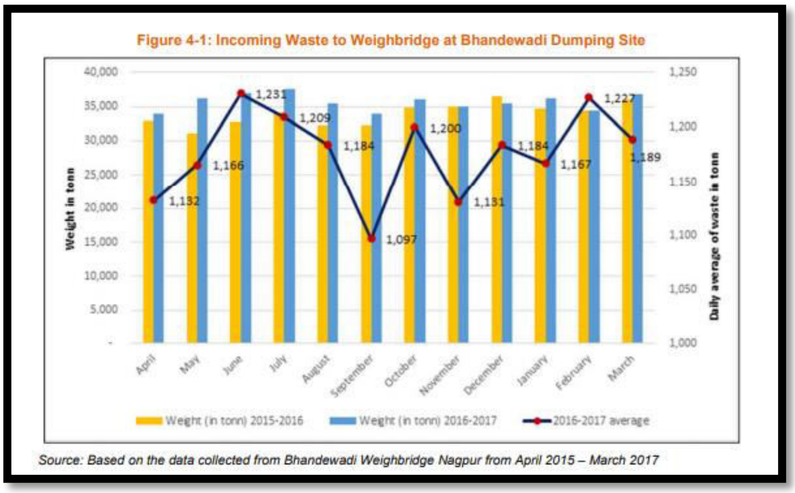
| Volume 10, Issue 3, May 2023 |



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

Waste Characterisation-

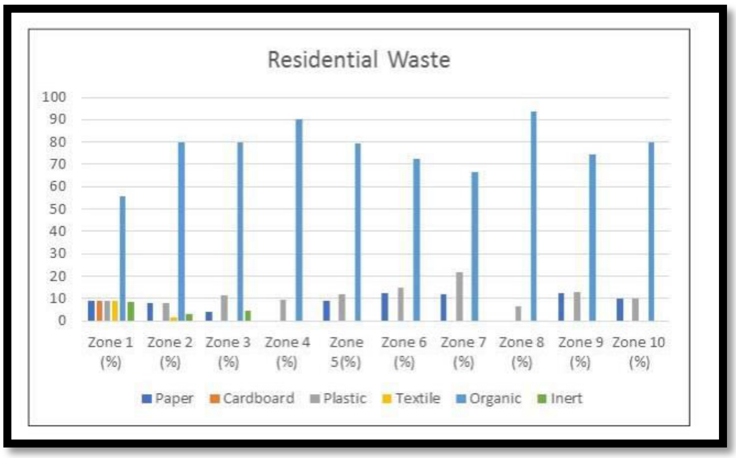
A waste characterisation exercise for Nagpur city was undertaken by the National Environmental Engineering Research Institute (NEERI), Nagpur. A total of 34 samples were collected from all the 10 zones in the city. Reconnaissance survey and fieldwork was carried out April/Mai, 2017. The locations for 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.

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)

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.
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. The existing waste management scenario is discussed in more detail further in this section.

4.2 Collection& Transportation

4.2.1 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, Balabhaupeth, Korali, Mankapur, Gaddigudam in zone IX.

4.2.2 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.

4.2.3 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.

4.3 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. Table 5-1 provides details of secondary storage points in each zone, including bins and transfer stations. The waste collected by door-to-door activity is transferred to a refuse compactor and further transported to the dumpsite - except for the zones which are served by transfer stations. This system requires a lot of coordination among the drivers of the refuse compactors and the waste collectors. The role of supervisors is also important to ensure overall co-ordination among all the operators and to ensure the timely availability of refuse compactors at designated points.
The main drawback of the system is that in the absence of coordination and non-availability of bins and other associated infrastructure, temporary roadside dumping has become prevalent.

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| Volume 10, Issue 3, May 2023 |

Table 5-1: Details of Secondary Storage Points in the NMC Area

Zone Number	Name of Zone	Total Number Secondary Point	Detail of Transfer stations
1	Laxmi Nagar	20	Sita Nagar (Temporary) Rahate Colony (Temporary)
2	Dharampeth	19	Ambajhari T- Point (Temporary)
3	Hanuman Nagar	14	Budhwari Bazaar, Sakkardara (Permanent)
4	Dhantoli	30	Ganesh Peth (Temporary)
5	Neharu Nagar	12	Tajbag Maidan (Temporary)
6	Gandhibagh	15	Sokhta Bhawan

56

(Table 5-1: Details of Secondary Storage Points in the NMC Area)

Zone Number	Name of Zone	Total Number Secondary Point	Detail of Transfer stations
			(Temporary)
7	Satranjipura	16	
8	Lakadgang	10	Gangabai Ghat (Temporary)
9	Ashi Nagar	13	Gangabai Ghat (Temporary)
10	Mangalwari	21	Chaoni Chowk (Temporary)
		171	

Source: NMC, April/May 2017

(Table 5-1: Details of Secondary Storage Points in the NMC Area)

IV. Technological Options for DSWM Treatment

There are a number of technologies such as recycling of waste, pit composting, vermi-composting and small scale anaerobic digestion (Bio-Gas) available for decentralized solid waste management. The selection of suitable technologies in the Indian context depends on various factors such as climate, techno-economic viability and size of the cities. The important parameters which are generally considered for suitability are quantity of waste generation, land availability, environmental sensitivity to locations, capital investment, costrecovery, etc. The high moisture content, low calorific value, substantially high contents of nitrogen, phosphorous and potassium in Solid Waste samples indicate that the vegetative fractions of waste are more suitable for composting to organic manure after separating the reusable and recyclable fractions. The inert, non-biogradable residue left after composting could be disposed of using sanitary landfill (Varma, n.a). These technologies are discussed in detail in the following paragraphs.

Recycling of waste:

Recyling of waste is mostly undertaken by the informal sector which includes waste pickers, kabariwala, scrap dealer and recycling units. It can also be done by residents themselves or with the assistance of voluntary agencies. Recycling materials are still collected by ragpickers and passed into the recycling stream. Segregation of waste is an important activity for the recycling of waste but it is generally not carried out in India. Mixed waste can neither be recycled nor composted. Recycling of waste saves space in landfills and reduces pollution.

Recycling of used materials is another major productive area in which considerable quantity can be utilized for manufacturing new products. Paper, plastics, card board, and metal can be converted into useful products. Paper can be made from waste paper and even from other waste materials such as old clothes, rags and crop leftovers and can be converted to shopping bags, shoulder bags, tiffin carrier bags, jhola bags, mats etc. Shopping bags can be converted to ecofriendly recycled products. Cloth bags may prove ecologically sustainable alternatives to plastic bags. The Coorg Municipality in Karnataka has been recycling the plastic carry bags with poly looms.

The product is designed keeping in view with the present trend of the market. It creates new business opportunities with minimum investments and space requirement. The technology has led to increase job opportunities among women due to its easy and user friendly process. Centre for Environment Education (CEE) has been awarded the 'Plasticon 2005 Award' on 1st October 2005 in Mumbai by the PlastIndia Foundation in category of 'Innovation in Recycling Technology' for its innovation of a 'polyloom'. Polyloom is a plastic weaving handloom that helps reuse and recycling of discarded plastic bags. The first CEE-ERU was established in Coorg, Karnataka and subsequently, through various CEE Offices in Ahmedabad, Coimbatore, Delhi, Goa, Patna and Tirupathi (World Bank Institute, IPE and CEE, n.a).Data shows that there are 1777 known plastic recycling units in India. Most of these units are located in Tamil Nadu (588), Gujarat (365), Karnataka (302), Kerala (193) and Madhya Pradesh (179). The total number of plastic recycling units and the capacity of each of these units are unknown (Annepu, 2012). The economics of recycling units encompasses a medley issues which includes collection costs for disposed materials, market demand for recycled product, landfill costs saved as a result of recycling the product and industrial infrastructure and technology available. From an economic perspective recycling pays only when additional costs of collection materials, sorting them for recycling and finally recycling and marketing them is substantially recovered from the value of the recycled product.However, kabadiwalas and ragpickers in Delhi have found themselves sidelined by the draft municipal solid waste rules, 2013 which does not recognized their contribution to the city's waste management. There is need to give them proper recognition in the society (Nandi, 2013). Despite playing a major role in collection and recycling of waste in cities, their work is mentioned only once in the draft rules which say the municipal body can engage agencies and groups 'including ragpickers' in collection of waste from homes, leaving it to the will of the corporation to decide whether or not they will avail their service at all (Nandi, 2013). Due to absence of segregation of waste at source, the quality of recycled products are generally poor and incapable of finding markets which is occupied by virgin materials based products. In addition to this, recycled products are largely neglected because of the absence of policy for recyclable products.

Decentralized Composting:
Decentralized composting can be operated by an appropriate technology and implemented at reduced investment and operating costs. Manual composting in small, decentralized plants is more easily integrated in the prevailing Indian level of development and socioeconomic background, as it requires labour intensive processes. It also offers new employment opportunities and a source of income to the under privileged in the Indian society. Considering these benefits, various small scale decentralized composting schemes are initiated by Non-Governmental Organizations (NGOs), Community-based Organizations (CBOs) often receiving some international assistance. The schemes can be seen as promising management and treatment options for urban areas as they enhance environmental awareness in a community allowing close quality surveillance of the service and product (Zurbrugg, et al., 2004). Cities like Bangaluru, Chennai, Mumbai and Pune have very active community based and decentralized composting schemes by which separated waste is turned into high quality compost (World Bank, 2008). Research documents reveals that the community based decentralized composting can generally process about 2 to 50 tons of waste per day depending on the community size and volume of compostable materials, while composting facilities are capable of receiving 10 to 200 tons of waste per day. However, composting is still not officially accepted as manure or soil conditioner and is rarely financially competitive to heavily subsidized chemical fertilizers and traditional cow dung or poultry manure. Farmers generally use urea for agricultural purposes without taking care of fertility of soil. The market for compost is still underdevelopment despite its potential (Zurbrugg, et al., 2004). Marketing of compost is a major problem in India.

Pit Composting:
The basic structure of the above ground pit has small horizontal air pipe on the walls. These pipes act as air holes allowing air to get into the garbage heap. This supplements the air circulation in the pit and thereby hastens compositing. Each pit has a dimension of 9x4x3 ft (World Bank Institute, IPE, CEE, n.a). It generally takes one month time to prepare compost (Mani, 2013).

(Fig.4.1: Pit Composting)

The underground composting proceeds are more slowly than above ground setup because it doesn't have access to as much fresh oxygen as above ground piles. Cities like Pune and Goa are using pit compositing at the household level. The Pune Municipal Corporation has made pit compositing mandatory for all housing societies constructed after year 2000 to build their own composting pits and process wet waste within the premises. The Corporation has established a mechanism through citizens' committee in each neighbourhood to get periodic updates on the functioning of compost pit once they are build, create a pool of 'certified or approved' service providers who could take care of the maintenance and operation of compost pits. Pit composting reduces the demand for future landfill space to serve the city as it grows.

Vermi Composting:

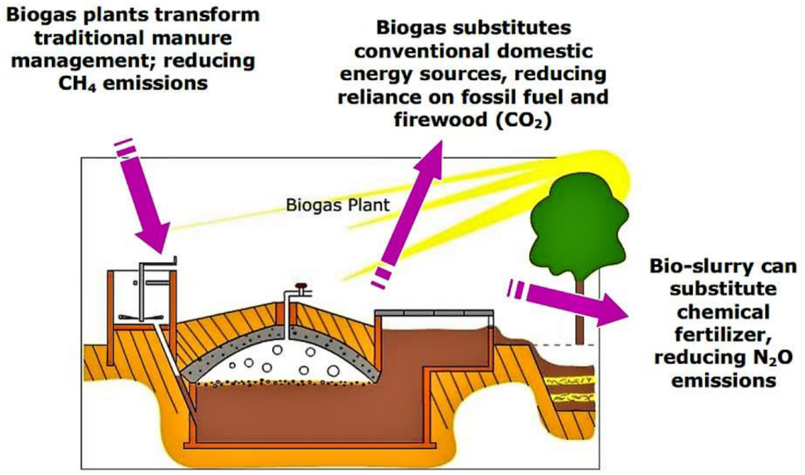
Vermi composting is a simple and effective process that can be done at the household level as it requires little space. Domestic wastes are mostly organic. It is estimated that each household produces not less than 200 kg of organic solid waste per year (Rajendran, 2008). Household composting involves waste preparation, waste degradation and finishing of waste. Waste needs to be sorted and prepared for rapid degradation. Once the waste is converted in to raw material for composting, the waste can be degraded. The degradation process should be controlled by maintaining adequate temperature, moisture and aeration. It is an effective method for treating pathogen rich wastes (MoUD, 2000) and has been adopted by many cities namely, Suryapet, Hyderabad, Bangaluru, Mumbai and Faridabad. It is pertinent to note that in any composting method, due to loss of moisture, recovery of compost from waste is only 25- 30 percent of wet waste composted (Mani, 2013).

(Fig. 4.2: Vermi Composting)

Small Scale Anaerobic Digestion (Bio-Gas):

Small scale bio-gas is a decentralized technology and the most environmentally friendly technology to recover energy from organic wastes .It serves as a waste disposal technology and help to solve solid waste environmental problems. It is extremely appropriate to ecological and economic demands of the future as it provide pollution free environment, efficient energy for cooking and lighting. Bio-gas is generated when bacteria degrade biological material in the absence of oxygen in a process known as anaerobic digestion. It mainly constitutes methane and carbon dioxide and the unit can be connected directly to a cooking stove. Since it is mixture of methane and carbon dioxide, it is a renewable fuel produced from waste treatment. It provides a clean, easily controlled source of renewable energy from organic waste materials. It has been very successful technology in India. Many households have installed such bio gas units in their houses. Total number of units installed in cities is unknown due to numerous companies offering this technology. A private company known as BIO-TECH alone installed 20,000 units of small scale Bio Gas in Thiruvananthapuram and Kochi. A single household in Thiruvananthapuram and Kochi produce 0.5-0.85 kg per day and 1.1-2 kg per day respectively (depending on the number of persons in the house) (Annepu, 2012). The potential use of this gas is for cooking purposes and to produce electricity in a dual fuel biogas-diesel engine. The manure generated is high quality and can be used for gardening and agricultural purposes (World Bank Institute, IPE and CEE, n.a.).

Another company known as ARTI has developed a compact bio gas plant which uses waste food rather than dung/manure as feedstock to supply bio gas for cooking. About 2000 plants are currently in use both in urban and rural households in Maharashtra.



(Fig.4.3 :Small Scale Anaerobic Digestion (Bio-Gas) Process)

(Fig.4.4 :Small Scale Anaerobic Digestion (Bio-Gas))

The company has won the 'Ashden Award for Sustainable Energy 2006' in the Food Security category that makes it the only company in the world to win the prestigious Ashden Award twice. ARTI won its first Ashden Award in 2002 for its chain of technologies for converting agricultural waste into charcoal. The benefit of compact bio gas plant is savings in cost as compared to the use of kerosene or LPG for cooking. This technology offers a solution not only for domestic waste disposal but also for collective disposal of community waste. People can avail this technology to convert starchy waste into clean useful energy (www.arti-india.org/..accessed on 10-07- 2013).The analysis of the technologies for decentralized waste management indicates that no technology is perfect. All of them have advantages and disadvantages as well. The selection of suitable technology lies on the extent of waste segregation at source which is not in practice as yet in India. Appropriate segregation of wastes can improve the quality of the compost and recycled materials that can solve the problem of marketing of these products.

CONCLUSION

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.

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