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Solid Waste Management in PCMC (3R's Principle)

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Abstract: ***Solid waste is inevitable task in urbanization process and it will increase in future. The collection, segregation, storage, transports and processing of solid waste needs planning and more investment. India is experiencing tremendous growth in urban areas which produce 120,000 tonnes of solid waste per day. Some metropolitan cities like Mumbai, Calcutta, Bengaluru, and Pune showing typical urban pollution. Among these Pune is also one of the cities which produce large quantity (1000-2000 MT/day) of Municipal Solid Waste (MSW).Study involves the Solid waste Management system in PCMC (Pimpri Chinchwad Municipal Corporation). Prepare and submit an action plan of 3R cycle to PCMC regarding Solid Waste Management which gives maximum collection efficiency and route cost optimization. The methodology involved locating the bin positions, mapping collection points and routes of vehicle, assessing waste characteristics through sampling.75 percent of total waste can be reduced from going to landfill by practicing 3R's.This will not only reduce pollution caused by dumping but also make today's waste as tomorrow's resource.***

Keywords: Solid Waste Management, 3R's Cycle, Route Cost optimization, MSW, collection efficiency

1. Introduction

1.1 India Situation

During the previous two-and-a-half decades, India's economic growth has been among the most rapid in the world with experiencing tremendous growth in urban areas. This increased urbanization associated with growing economy has posed a significance stress on the environment. The scenario in India is also alarming as MSW is expected to increase from 85 million tons in 2011 to 300 million tons by 2047(Ministry of Urban Development, 2000). Studies have shown that per capita waste generation in India is increasing by about 1.3% per year. The urban population is growing at the rate ranging between 3 to 3.5% per annum; which will lead to increase in overall quantity of solid waste by about 5% (Ministry of Finance, 2009).

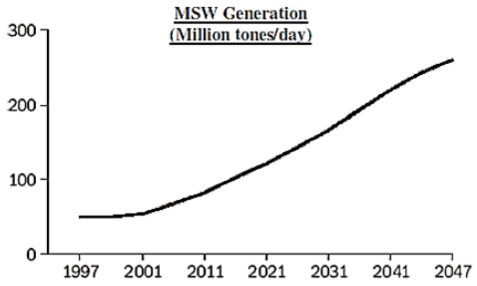

Figure 1-Waste Generation Rate in India (MoF, 2009)

1.2 PCMC Situation

The twin city (Pimpri Chinchwad) is governed by the Pimpri Chinchwad Municipal Corporation (PCMC). PCMC and Pune, when viewed as a unified geographical unit, make up one of India's largest industrial areas.

Accordingly, the population reached to 17.29 lakh in 2011 and estimated to reach 21.50 lakhs in 2021 and over 29 lakhs in 2031 (Environmental Status Report 12-13). The population of Pimpri Chinchwad in the last two decades grew at an annual average rate of over 7% against the national average of 2.1% and state average of about 3.3%.PCMC area is generating approximately 646 Metric Tons per Day (MTD) solid waste as given in ESR (12-13).

1.3 Municipal Solid Waste

MSW defined to include refuse from households, hazardous solid waste from industrial and commercial establishments, refuse form institutions, market waste, yard waste and street sweeping (World Bank, 1994). The nature of MSW being variable in both quantity and characteristics makes Municipal Solid Waste Management (MSWM) a challenging task. The management practice has to address generation, sorting, collection, transportation and processing.

Table 1: Overview of SW (ESR-2012-13)

Population of PCMC area (2011)	17.29 lakh
Area of dumping site	81 Acre
Total waste generation	646 MTD
Per capita generation	350 gm.
Total waste collection	452 MTD
Waste dumped	312 MTD
Staff for Solid Waste Management	2798 nos.
No. of vehicles used for disposal of Solid waste to facilities	Primary: 362 Secondary: 66

Waste generation is found to directly proportional to the level of affluence or income and likely to increase at more rates for lower income and lower middle income group as shown by World Bank.

2. Literature Review

Various reports of NEERI (National Environmental Engineering Research Institute), CPCB (Central Pollution Control Board), ISWA (Indian Solid Waste Act), JNNURM (Jawaharlal Nehru National Urban Renewal Mission), World Bank, NGOs (Non-Governmental Organizations) to understand practice of waste management across the world and within India, economics of the sector, its impact on livelihoods, principles of zero waste management and decentralized systems, role of formal and informal sectors, and linkages between various institutions or stakeholders.

2.1 Generation

Waste is generated from various sources as residential, commercial, institutional buildings and municipal services as street sweepings, recreational areas (Environmental Information System, 2009). The main components are organic i.e. food and kitchen waste; recyclables as plastic, paper, cardboard etc., composites as rags, toys; inert as soil, construction and demolition debris and domestic hazardous waste as tube lights, spray, batteries (ENVIS 2009). The percentage composition of each type of waste varies according to the type of generator, their income level, standard of living i.e. food habits, degree of commercial activities and seasons and availability of resources (Sharholy, 2008).

2.2 Collection

Common practice of collection in India is to collect waste from source to common point and then to vehicle. Collection happens at two levels and by two different agencies in most cases: (a) primary collection from source to common collection point and (b) secondary collection from collection point to collection vehicle (MoUD, 2000) (UNHabitat, 2010).

Collection efficiency of MSW depends on generation rate, population growth, vehicle capacity, vehicle availability. Collection efficiency is calculated using waste collected per day against waste generation per day.

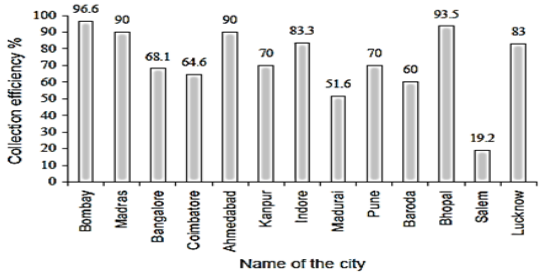

Figure 2: Collection Efficiency of Cities (Sharholy 2008)

2.3 Transportation

The functional element of transportation involves two steps (MoUD, 2000), one is the transfer of wastes from the smaller collection vehicle to the larger transport equipment and other is his subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station. Various types of vehicles such as compactor trucks, dumpers, Small Closed Vehicles (SCVs) are used mostly for transportation (UNHabitat, 2010). Waste is transported from the collection points to the landfill site every day.

2.4 Processing

Waste processing leads to reduction in the volume, weight, size or toxicity of waste without resource recovery and it can be done by a variety of mechanical (e.g. shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques (MoUD, 2000).

Biological treatment involves using micro-organisms to decompose the biodegradable components of waste by aerobic and anaerobic process. Aerobic processes are Windrow composting, aerated static pile composting and in-vessel composting; vermi-culture etc. and Anaerobic processes are Low-solids anaerobic digestion (wet process), high solids anaerobic digestion (dry process) and combined processes. Thermal treatment involves conversion of waste into gaseous, liquid and solid conversion products with concurrent or subsequent release of heat energy (MoUD, 2000). Incineration, RDF, pyrolysis technologies are still developing in India (Sharholy, 2008).

2.5 Disposal

A parallel system of rag-pickers helps in recycling of valuable waste material at source as well as at the disposal level. In search of more valuable waste such as better quality plastic, the rag-pickers used to shove their hands and feet in the waste, exposing themselves to the stink and to the skin diseases.

Landfilling is the most common practice in many countries that involve burying the waste. It is comparatively inexpensive technique of waste disposal that avoids serious threat to community health represented by open dumping. A sanitary landfill is more hygienic and built in a methodical manner. The sanitary landfills are lined with materials that are impermeable such as HDP liners. Waste deposited in sanitary landfills is normally compacted to increase its density and stability. In landfill, the organic waste undergoes natural decomposition and generates a fluid, which is known as leachate, and is very harmful to the ecosystem.

Decomposition and stabilization of organic matter under controlled condition is known as *composting*. Organic waste materials are recycled using biological composting and digestion processes. In composting, micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. The resulting organic material is then used for agricultural or landscaping purposes. It increases the soil's ability to hold water and makes the soil easier to cultivate.

Vermi-composting is a successful waste disposal technique followed at community level. In order to address the organic waste management in the city, PCMC called for a meeting. The meeting addressed to solve the overall problem of the City's Waste Management was attended by NGOs and other agencies.

2.6 Concepts of Zero Waste

Zero Waste Mission-"Strengthen the waste handling infrastructure builds the capacity of human and economic resources and improves accessibility of services to enhance the efficiency of existing WM practice. Promote and establish sustainable models to maximize resource recovery by using participatory and decentralize approach and to reduce burden on the ecosystem by reducing waste generation."

The quantity and type of waste generated is function of standard of living, level of affluence, lifestyle adopted and availability of resources (SWM, UNEP, 2006).Waste management (WM) is very crucial as it involves several stages starting from the source of generation till the final disposal (MoUD, 2000).

3. Methodology

3.1 Secondary Data Collection:

Worldwide Web gives Collection of basic information about study area such as maps, demography, area, special features and Gather information about role of stakeholders in existing waste management practices, case studies and technology related information. Records maintained by Municipal Corporation (ward office) gives Weight data for collection vehicles, fuel consumption of collection vehicles Records maintained by ward supervisor (SWM Department) gives total number of vehicles plying in the area, total number of households served, routes of collection vehicles.

3.2 Situation Analysis of Study Area

3.2.1 Generation

At this stage we carried out survey of collection points which includes location, no of bins and its capacity, volumetric waste generation, per capita waste generation, type of collection vehicle, commercial and housekeeping activities such as weekends, cleaning, maintenance etc. Also survey of open dumping, waste characterization (sorting, compostable, recyclable and waste composition.)

PCMC area generates about 646 MTD of solid waste. Thus, the waste generated from residential area contains high moisture and organic matter, while office-dominated areas produce dry wastes. Usually, the wet waste consists of biodegradable matter coming from the kitchen. Dry waste consists of recyclable materials like paper, rubber, glass, ferrous-nonferrous metals, cardboard etc., which are estimated to be 40 and 60% in the residential and commercial areas respectively hence we should have to focus on these areas for segregation.

Segregation of waste has to be started at the most convenient point, namely the household. Residents segregate dry and wet waste along with recyclable materials like glass and metal at household level. Municipality should have to looking forward to providing dustbins for segregation of waste at source under JnNURM and NGO's like Bharat Vikas Group Kshitij Waste Management Services Pvt. Ltd.

Table 2: Sector-wise generation of solid waste (ESR-2012)

Waste Type	Sector wise Generation in percentage			
	A	B	C	D
Vegetable Market	2.04	3.04	3.65	4.04
Household	84.24	82.04	82.11	86.59
Commercial	2.48	3.12	3.55	2.45
Hotel & Restaurant	10.12	10.39	10.69	6.92
Slaughter house waste	-	1.41	-	-

Table 3: Percentage wise distribution of MSW

Sr.No.	Component	%
1	Food waste	62.9
2	Garden waste	18.65
3	Paper	1.85
4	Plastic & Rubber	1.23
5	Glass	0.001
6	Metal	0.01
7	Wood	0.04
8	Miscellaneous (textile, dirt, bricks, stones)	15.33
Total		**100**

3.2.2 Collection

At collection point we survey collection service and sorting (high, middle and low income groups) at household and stakeholders Kabadiwalas at collection points. We assigned collection routes and vehicles according to maximum collection efficiency with minimum time and cost.

The PCMC has introduced a "Ghanta-Gadi" (Belled Waste Carriage) to collect waste from households. The housewives preferred this arrangement, as it does not involve any cost, whereas, disposal of waste through rag pickers meant an expense of Rs. 10 every month per household. Roadside dustbins (size 4.5 cu.m.) have been placed in the city for primary collection of the waste at a distance 80-100m but at some points the distance is too large. People find this distance not reasonable. Hence we prepared the route map and dustbins were provided at required points. This method increases collection efficiency and avoid habits of throwing waste in open area.

PCMC has setup ramps at various locations in the city. The solid waste from each collection point is brought to these ramps by dumper placers and other small collection vehicle, it is further transformed in compactors and then the waste is moved to Moshi landfill site. At these ramps MSW should have to be fully segregated Hence we planned we planned centralized segregation also which can also done by waste pickers, Rag pickers and Kabadiwalas. This method saves the 70% of waste which is going to landfill.

3.2.3Transportation-

Waste is transported from the collection points to the landfill site Moshi every day. We planned vehicles for transport of waste at Moshi with route cost optimization and time for zone A. For primary collection total 46 (Ghanta-Gadi) vehicles were assigned which collects waste from societies and household to the ramp point. Also 4 Compactor assigned for transport of waste from ramp to Moshi.4 Dumper placer also plays important role for transporting large bins direct to Moshi.

The schedule of all vehicle prepared which includes time, capacity of bin, route and ward no. Also record of fuel, condition and maintenance of vehicle were carried out. Sometime vehicles were in non-operating condition then other vehicles collect waste in the form of shifts. Separate vehicle assigned for hotel waste collection, celebrations, programmers, parties.

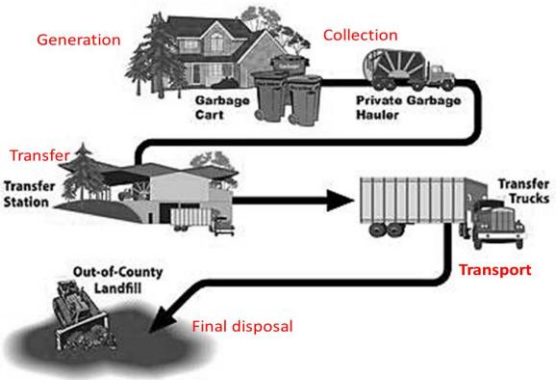

Figure 2- MSW Management Method

3.2.4 Processing-

We survey the biomedical treatment, recycle of waste. Biomedical Waste treatment facility in should be Incineration ash (Hazardous facility Maharashtra Enviro Power Ltd., Ranjangaon), Treated solid waste (Municipal landfill), Plastic waste after disinfection and shredding (recycling or municipal landfill), Treated wastewater (Sewer/drain or recycling), Oil & grease (incineration).

PCMC should produce hydrocarbon fuel from plastic, collected from MSW at Moshi Kachara Depot as maximum as possible. The city based Bharat Vikas Group Waste Management Ltd. (BVG) has developed a technological process for producing fuel from all types of plastic wastes. The plant is capable of producing 600-700 litre of hydrocarbon fuel from 1 MT of waste plastic. This particular waste to fuel plant is of extreme importance towards finding the solution to the ever-worsening problem of plastic waste.

3.3.5 Disposal:

We visited disposal site Moshi and surveyed the recover potential of ground, calorific value and bulk density of waste sample. Characteristics of processed lechate are presently higher than MSW Standards. However, PCMC should have to undertake a project to further treat the lechate chemically and biologically. At the Moshi landfill site, a mechanical composting unit is operational in the area of 6.48 ha. The mechanical compost unit, having the capacity to treat 500 MTD of waste, presently treats 250-330 MTD of solid waste. Vermicomposting plant having the capacity of 30 MTD is operational at the Moshi site in an area of 2.02 ha. Presently, the plant treats 12-15 MTD of collected waste as well as the STP sludge.

Table 4: Characteristics of leachates generated from Moshi landfill site as well as Mechanical composting

Parameters	MSW Standard MSW (M&H) 2000 Standard	Concentration	
		Untreated leachate	Treated leachate
pH	5.5	8.9	9.3
COD(mg/l)	-	23200	3840
BOD(mg/l)	100	6960	1100
TSS (mg/l)	200	2584	1272
Total dissolved solids (mg/l)	2100	2926	1854
Chloride (mg/l)	600	4448	2524

Different ionic concentrations including heavy metals were substantially increased (5.7 – 109%) in compost sample over biodegradable MSW. Surface soil, below the compost at dumping site acquired higher concentrations (15 – 800 %) of different pollutants from those of control soil. Leachability rates of certain pollutants viz. Na, K, Zn, Cu, Mn, Mg were remarkably high (7 – 83%) from surface soil to a level up to 1.2 m downward**.** However a reverse trend was observed exhibiting poor leachability rate of the metals Co, Cr, Pb & Ni was observed, where the concentration were more (11 – 75%) at surface soils then those at soils below 1.2 m deep.
Now Environmental Minister announced that the land at Punavale is allotted for landfilling. Hence it has greater importance in future landfilling and disposal.

3.3 Primary Data Collection-

Primary data collection was done by conducting structured and semi-structured interviews, informal interviews; email communications etc. with key stakeholders which includes NGOs, citizens, waste pickers, scrap-dealers (Kabadiwalas) and formal recyclers at whole methodology. The purpose of this activity was to understand the existing recycling practices, access to waste and the economics involved in it. Waste management (WM) is very crucial as it involves several stages starting from the source of generation till the final disposal (MoUD, 2000). We also collected information related to health hazard from the public living nearby areas around the disposal site. City development report, Environment report and transportation report has provided data input for the study. The solid waste management system of the metro cities such as Mumbai, Delhi, Kolkata and Chennai is also studied as zero waste initiatives.

Table 5-Zero Waste goals and Objectives

Goals	Objectives
Improve efficiency of current waste handling practices	• Comply with regulatory requirements of MSW rules • Improve the collection, segregation practice in the area • Impart transparency, accountability, efficiency in operations
Strengthen infrastructure to promote resource recovery	• Build internal capacity of Corporation in terms of human & capital resources • Strengthen association with various stakeholders to implement the tasks and achieve above goals • Impart sense of ownership and involvement in community
Reduce burden on the ecosystem	• Minimize quantity of waste generated, transported and landfilled • Incentivize hygienic waste handling practices • Avoid exposure of waste to natural resources as soil, water, air

3.4 Action Plan

Issues in MSWM are no system of door to door collection of waste, no segregation of waste at source, Inadequate community bin facilities, Burning of waste on roads/ bins, People throwing waste on streets, open space, drains, nalas etc., No separate system for collecting of disposal of construction waste and /or Industrial waste, Problem of hotel

& restaurant waste, No system of collection of garden waste, Issue of plastic begs / plastic with less than 20 microns, Crude dumping of waste, Use of Plastic begs / plastic thinner than 20 micron, Lacking of public awareness, High level of subsidy and low level of recovery for SW service.

Municipal Corporation should have to strengthen its capacity and institutional arrangement to handle all solid waste in City. To handle all the solid waste in city, Municipal Corporation must take help of NGO's, researchers, universities and colleges. People's participation is essential to ensure a well-managed system. There is also need to conduct an education campaign on waste management and health related issues. Also NGO's (Janwani) and environmental sustainable companies (Teri) should have to arrange seminars, street plays. Also Municipal Corporation must spread messages through radio, television, newspapers and hoarding about the advantages of clean city. Such efforts will reduce the open waste and waste at storage sites. There is need of scientific planning of the solid waste collection at each household, collection points and easiest way of transportation up to land fill sites. An increase in population has put tremendous pressure on budgetary resources. The unbundling of services and technological innovations have opened up these areas to private sector participation (MoF 2009, Clairair O. S. 2006). Training & Public Awareness, Scientific approach for Sweeping, Waste Segregation and Reuse, Provision of Adequate Collection Facilities, Developing Strong Transportation Facilities, Setting up Transfer Stations, Augmentation of Waste Processing, 100% daily sweeping to entire city population,100% Waste Collection system before end of year,75% waste segregation at collection, 95% SW processed before land filling, Development of Sanitary landfill site, Quick & Prompt complaint attendance for the utility, Dust Free Major roads.

Table 6: Action Plan for Zero Waste PCMC

Infrastructure Development	• Establish 'Performance Evaluation cell' with members from stakeholders as NGOs ALMs, CBOs, volunteers • Establish supporting cell for labour as part of co-operative of rag pickers
Capacity Building & Partnerships	• Policy amendment for strict enforcement of segregation practice • Redefine slum adoption scheme for waste collection from slums • Policy amendment to promote processing, Build common platform for knowledge sharing
Assessment & Development	• Redesign system with advanced technology usage and set up common resource pool • Optimization or Rationalization of collection Routes and Study • Promote and establish various financial models as PPP.
Awareness & Promotion-	• Promote segregation Launch Awareness campaign for Zero Waste • Launch Environment Action program for education Centre's • Arrange Environment Mela (Eco Mela) • Set up Green Cell3RBuild common platform for sharing knowledge and ideas • Establish sorting Centre's Promote decentralized processing of wet waste

4. Conclusion

The waste has several components which have potential to be reduced-reused–recycled. This potential is underutilized on account of lack of awareness among generators, lack of sense of ownership and responsibility, lack of sufficient infrastructure. 75 percent of total waste can be reduced from going to landfill by practicing 3R"s This will not only reduce pollution caused by dumping but also make today's waste as tomorrow's resource.

The action plan follows situation analyses followed by a thematic approach of building up infrastructure, capacity, awareness and assessment. Accordingly detailed Action sheets have been developed. The study presents a methodology and action planning process. The field application coupled with this guidance is expected to serve as a tool kit for applications elsewhere to develop a zero waste management plan for a ward in an urban area.

Also maximum collection efficiency, route cost optimization, Processing, composting, recovery with minimum landfilling, Health hazard, open dumping, burning of waste.

Bungalow Societies, Housing Societies, Slums, Gavthan, Commercial Establishments, SHGs (Self Help Group), schools, Senior citizens and other groups plays vital role in solid waste management of PCMC.

5. Future Scope

As population, living standard increases the generation of waste is continuous. Hence we should have to plan according to Population Forecasting, Use of GPS Tracking System, advanced processing and recycle technologies (Biological and thermal treatment) , diversity principle (More diverse most efficient planning), minimum waste to landfilling.

References

[1] "*Status Report on Municipal Solid Waste Management*" by Central Pollution Control Board (MoEF, 2000)
[2] Mufeed Sharholy "*Municipal solid waste characteristics and management in Allahabad, India*" by author Mufeed Sharholy
[3] MoUD. (2000). Manual on SWM.
[4] MSW Rules. (2000).
[5] JNNURM. (2009) "*Toolkit for Solid Waste Management*" MoUD, GoI.
[6] ENVIS 2009. (n.d.). Retrieved from ENVIS, Maharashtra.
[7] *PCMC ESR (2012-13)/solid waste/page (73-83)*
[8] Central Pollution Control Board (CPCB), 2000. Management of Municipal Solid Wastes. New Delhi, India
[9] "*Surat Solid Waste Management Project under*, JNNURM"
[10] "*SWM, Agra*" By Regional Centre for Urban & Environmental Studies
[11] Athena, I. I. (2012). "*PPPs in Municipal Solid Waste Management in India*."

[12] Detail Project Report (DPR) for "*Strengthening Primary and Secondary Solid Waste Management in the city"* No.: RMC/JnNURM/SWM01/0511

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