Developing the Idea of Zero Solid Waste City For Bhopal, India

Arti Jaiswal
PhD Research Scholar
MANIT Bhopal

Dr. Alka Bharat
Professor in Architecture and Planning Deptt.
MANIT Bhopal

Abstract

The nature of the city is dynamic and ever changing. The currently consumption-driven society produces an enormous volume of waste every day. The over-consuming society per capita waste generation is relatively higher in high-consuming cities compare to low-consuming cities. Transforming currently over-consuming cities into zero waste cities is challenging. The concept of the zero waste cities includes a 100% recycling of municipal solid waste and a 100% recovery of all resources from waste materials. The increasing problem of solid waste in Indian cities has become one of the most intractable environmental, economic and social problems today. Increase in volume of waste generated by urban residents, change in the quality of waste composition and the disposal method of waste collected are major concern. The present paper is an approach which discusses the problem of solid waste and develops the idea of zero waste. It attempts to reveal the issues concerned with solid waste in Bhopal. It focuses the problems identified in different literature for solid waste. The paper has been divided into three sections. Section one talks on the existing scenario of solid waste. Section two do literatures reviews and explains their finding. The paper finally tries to incorporate the zero waste city thought for Bhopal.

Key Words *– Waste generation, Waste composition, Integrated Solid Waste Management, Zero Waste.*

1. Introduction

Increasing population levels, rapid economic growth and rise in community living standard accelerates the generation rate of municipal solid waste (MSW) in Indian cities. Most State governments and urban agencies have identified solid waste as a major problem that has reached proportions requiring drastic measures. Increasing population and pollution in urban areas and particularly big cities coupled with ineffective management has led to serious environmental problems. Due to population growth, industrialization, urbanization and economic growth, a trend of significant increase in municipal solid waste generation has been recorded worldwide. MSW generation, in terms of kg/capita/day, has shown a positive correlation with economic development at world scale. Due to rapid industrial growth and migration of people from villages to cities, the urban population is increasing rapidly (Kaushal, Varghese, & Chabukdharan, 2012). Waste generation has been observed to increase annually in proportion to the rise in population and urbanization. The per capita generation of MSW has also increased tremendously with improved life style and social status of the populations in urban centers (Sharholy, Ahmad, Vaishya, & Gupta, 2007). A report published by World Bank estimates that at present almost 1.3 billion tonnes of MSW are generated globally every year, or 1.2 kg/capita/day. The actual per capita rates, however, are highly variable, as there are considerable differences in waste generation rates across countries, between cities, and even within cities. Solid waste is generally considered an 'urban' issue (Kidani, 2013). Waste generation rates tend to be much lower in rural areas since, on average, residents are store-bought usually poorer, purchase fewer items and have higher levels of reuse and recycling.

India, with a population of over 1.21 billion account for 17.5% of the world population. According to the provisional figures of Census of India 2011, 377 million people live in the urban areas of the country. This is 31.16 % of the Country's total population. India has 475 Urban Agglomerations (UA), three of which has population over 10 million (Census of India, 2011). The very high rate of urbanization coupled with improper planning and poor financial condition has made MSW management in Indian cities a challenging task.

In most Indian cities, the MSWM system comprises only four activities, i.e., waste generation, collection, transportation, and disposal. The quantity of MSW generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons. Data on quantity variation and generation are useful in planning for collection and disposal systems (Kaushal, Varghese, & Chabukdharan, 2012). Indian cities now generate eight times more MSW than they did in 1947 because of

increasing urbanization and changing life styles (Sharholy, Ahmad, Vaishya, & Gupta, 2007).
The rate of increase of MSW generated per capita is estimated at 1 to 1.33% annually (Sharholy, Ahmad, Mahmood, & Trivedi, 2008). MSW generation rates in small towns are lower than those of metro cities, and the per capita generation rate of MSW in India ranges from 0.25 to 0.5 kg/ day as per UDPFI guidelines.
Status report on Municipal Solid Waste Management by Central Pollution Control Board (CPCB) states that as per the report of Ministry of Urban Development, Government of India, 1,00,000 MT of MSW was generated daily in the country. During the year 2004-05, CPCB through National Environmental Engineering Research Institute (NEERI), Nagpur conducted survey in 59 cities (35 Metro cities and 24 State Capitals) and estimated 39,031 Tons per day MSW generation in these 59 cities/towns. As per information received from State Pollution Control Boards/ Pollution Control Committees (in between the year 2009-12), 1,27,486 TPD (Tons per day) municipal solid waste is generated in the Country during 2011-12. Out of which, 89,334 TPD (70%) of MSW is collected and 15,881 TPD (12.45%) is processed or treated. The huge amount of solid waste has become the major problem. The increasing problem of solid waste in Indian cities has become one of the most intractable environmental, economic and social problems today.

2. Literature Review

Urban solid waste includes household garbage and rubbish, street sweeping, construction and demolition debris, sanitation residues, trade and industrial refuse and bio-medical solid waste. SWM has three basic components, namely, collection, transportation and disposal. The objective of SWM is to reduce the quantity of solid waste disposed off on land by recovery of materials and energy from solid waste in a cost effective and environment friendly manner (Department of Economic Affairs, MoF, GoI, 2009).
(Kurian, Esakku, Nagendran, & Visvanathan, 2007) state that rapid population growth and urbanization in developing countries have led to the generation of enormous quantities of municipal solid wastes and consequential environmental degradation. Solid waste management has remained an intractable, environmental sanitation problem. This problem is compounded by the rapid urbanization and population growth which has led to the generation of enormous quantities of solid waste. Rapid increase in volume and types of solid and hazardous waste is a result of continuous economic growth, urbanization and industrialization.

2.1 Background Studies

Typically, domestic waste from industrial countries has a high content of packaging made of paper, plastic, glass, and metal, so the waste has low density. In many developing countries, domestic waste contains a large proportion of inert materials, such as sand, ash, dust, and stones, and has high moisture levels because of the high usage of fresh fruit and vegetables (Zhu, Asnani, Zurbrugg, Anapolsky, & Mani, 2008).
Studies have been explored to understand the generation of waste by consumption and the valuation of resources in current waste management practices. It is important to understand the drivers behind current overconsumption practices, the cause of the depletion of resources and the generation of the huge amount of waste in our everyday life. Two background studies have been explored to understand the generation of waste and valuation of resource in current practices based on two different contexts: (a) socio-economic context and (b) material flow context. It is important to understand the philosophy behind current overconsumption practices, the cause of the depletion of resources and the generation of the huge amount of waste in our everyday life.

2.2 Waste generation

To develop strategies to transform cities into zero waste cities it is important to discover the reasons why our society produces so much waste. Environmental ethics, valuation of resources, human behaviour, individual and social perceptions on waste and resources, social and environmental well-being, economic development, conservation of global resources, technical improvement, and the interrelations between these things are important to understand when developing holistic zero waste management systems. However, very few researchers have tried to establish the linkages between those aspects in a holistic point of view.

Solid wastes are any discarded (abandoned or considered waste-like) materials (Department of Environmental Conservation, 2013). The term solid waste means: material such as household garbage (includes recycling), food wastes, yard wastes, and demolition or construction debris. It also includes discarded items like household appliances, furniture, scrap metal, machinery, car parts and abandoned or junk vehicles (Public Health). (Smart Ranger, 2009) defines solid waste the useless and unwanted products in the solid state derived from the activities of and discarded by society. It is produced either by - product of production processes or arise from the domestic or commercial sector when objects or materials are discarded after use. MSW is the garbage that people produce in their homes and where they work. It

contains all kinds of garbage including newspapers, yard waste, old appliances, household garbage, used furniture and just about anything we can think of that people throw away at home, schools, and businesses. As per Toolkit for Solid Waste Management (Ministry of Urban Development, 2012) Waste generation encompasses activities in which materials are identified as no longer being of value (being in the present form) and are either thrown away or gathered together for disposal. Municipal Solid Waste consists of the following kinds of waste.

Figure 1. Source of MSW Generation

Thus solid becomes waste when it becomes useless and harmful. The problem can be reduced and zero wastes concept can be achieved by reducing its amount, recovery of waste and making it harm free and useful.

2.3 Waste Composition and its Characteristics

As compare to the western countries, MSW differs greatly with regard to the composition and hazardous nature, in India. Many categories of MSW are found such as food waste, rubbish, commercial waste, institutional waste, street sweeping waste, industrial waste, construction and demolition waste, and sanitation waste. MSW contains compostable organic matter (fruit and vegetable peels, food waste), recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), and soiled waste (blood stained cotton, sanitary napkins, disposable syringes). MSW composition at generation sources and collection points, determined on a wet weight basis, consists mainly of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%) (Sharholy, Ahmad, Mahmood, & Trivedi, 2008).
MSW characteristics depend on the type of activity from which it is produced; such as households, commercial shops, hotels & restaurants, markets and mass storage units, institutions and offices etc. Waste composition basically indicates the Physical Characteristics and Chemical Characteristics of waste. Typical physical and chemical characterization waste for Indian Cities has been found as follows;

Table 1. Physical and Chemical Characteristics of MSW in Indian cities

Population Range (in millions) →	0.1 to 0.5	0.5 to 1.0	1.0 to 2.0	2.0 to 5.0	> 5
Physical Characteristics					
Paper (as %)	2.91	2.95	4.71	3.18	6.43
Rubber Leather And Synthetics (as %)	0.78	0.73	0.71	0.48	0.28
Glass (as %)	0.56	0.35	0.46	0.48	0.94
Metals (as %)	0.33	0.32	0.49	0.59	0.8
Total compostable matter (as %)	44.57	40.04	38.95	56.67	30.84
Inert (as %)	43.59	48.38	44.73	49.07	53.9
Chemical Characteristics					
Moisture (as %)	25.81	19.52	26.98	21.03	38.72
Organic matter (as %)	37.09	25.14	26.89	25.6	39.07
Nitrogen as Total Nitrogen (as %)	0.71	0.66	0.64	0.56	0.56
Phosphorous as P2O5(as %)	0.63	0.56	0.82	0.69	0.52
Potassium as K2O(as %)	0.83	0.69	0.72	0.78	0.52
C/N Ration	30.94	21.13	23.68	22.45	30.11
Calorific value* in Kcal/kg	1009.89	900.61	980.05	907.18	800.7

Source: Manual on Municipal Solid Waste Management 2000 – CPHEEO

To handle the different type of waste for its best management, integrated solid waste management planning might be a good approach.

2.4 Integrated Solid Waste Management (ISWM)

In the context of ISWM, waste is regarded both as a negative and as a useful material providing a potential source of income. It can in fact be the only free resource available to poor people, or urban dwellers, who cannot cut wood or use other common property resources available in the country. ISWM recognizes three important dimensions in waste management: (1) stakeholders, (2) waste system elements and (3) sustainability aspects. It is very useful to design of new systems and selection of new technologies. It talks about waste prevention and reduction, recycling, separation at source systems and selective collection, selection of new technologies.
The concept of ISWM based on its generation from different sources including domestic, commercial, industrial and agriculture. This waste could be further classified as hazardous and non-hazardous waste (Figure 2). The former has to be segregated at source and treated for disposal in accordance with the strict regulations. 3R approach (reduce, reuse and recycle) is applicable both at source as well as at the different levels of solid waste management chain including

collection, transportation, treatment and disposal (UNEP, 2009).

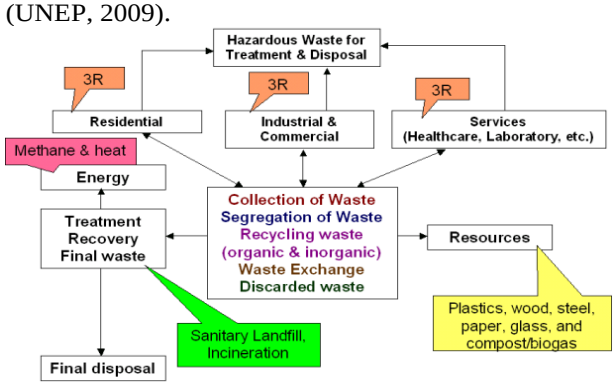

Figure 2. Generation Based ISWM (UNEP, 2009)

From the solid waste generation perspective, waste generation can be typically classified as:

☐ Municipal Solid Waste including household waste and commercial waste
☐ Construction and Demolition waste
☐ Hazardous solid wastes
☐ Bio-medical waste
☐ Electronic waste

The quantity of solid waste generated, as well as its ever changing characteristics, is at an alarmingly increasing proposition. It is require going for 'Zero Waste City' concept to solve these problems in a sustainable manner.

3. Zero Waste City Concept

According to Atiq Uz Zaman and Professor Steffen Lehmann of Zero Waste SA Research Centre for Sustainable Design and Behaviour, School of Art, Architecture and Design, University of South Australia states designing sustainable cities is very challenging. Among in all key challenges, waste management is one of the most important challenges for sustainable city design. In high consumption cities in the industrialized world, large amounts of paper waste, over-packaging, food waste, and e-waste are all causing particular problems. "Zero waste" means designing and managing products and processes systematically to avoid and eliminate the waste and materials, and to conserve and recover all resources from waste streams. Therefore, zero waste cities would recycle 100 per cent of their waste or recover all possible resources from waste streams and produce no harmful waste for our environment. From the holistic point of view, designing zero waste cities is relatively hard to achieve.

3.1 Approach for Transforming a City into a "Zero Waste City"

Both global economic growth and consumption rate have increased significantly all around the globe. Waste generation trends indicate that waste volume reduction is one of the key challenges for all cities. (Zaman & Lehmann, 2011) identified five core aspects that are most important in transforming cities into zero waste cities. The tools, methods, or strategies developed for recycling or managing waste in zero waste cities should be affordable in the socio-economic context, regulatory or manageable in the socio-political context, applicable in the policy and technological context, effective or efficient in the context of economy and technology, and finally all these aspects should be directly related to environmental sustainability.

To achieve zero waste city objectives, they propose five inter-connected key principles that need to be applied simultaneously for transforming a city into a zero waste city. The principles are:

1. Behaviour change and sustainable consumption
2. Extended producer and consumer responsibility
3. 100% recycling of municipal solid waste
4. Legislated zero landfill and incineration
5. 100% resource recovery from waste

The zero waste city principles are developed based on waste hierarchy, i.e. avoid, minimization and recovery. Behaviour change and sustainable consumption practice will avoid the unnecessary waste generation from product production and use phases. Extended producer and consumer responsibility will ensure the sustainable choice of resource use and ownership of personal waste generation and management. An increased sense of responsibility will also lead to avoidance of waste generation. By achieving total recycling of waste and legislation for zero landfill and incineration, a 100% recovery of resources would be possible in the zero waste cities and thus ensuring the minimum depletion of finite natural resources.

Thus waste management in a way which can transform waste into valuable stuff or at least harm free might lead towards Zero Waste City.

4. Challenges and Opportunity for Zero Waste City: A case of Bhopal

Cities have been recognized as engines of growth. As healthy mind needs a healthy body so do citizens need healthy environment to live and work. There are many factors which create a healthy liveable space for the citizen and there is a complex correlation between them, and this correlation is a derivative of time. The social and behavioural change is the result of economic growth and modernization. Change in the amount of

waste generation and its diverse composition is also an outcome of social and economic changes.
Solid Waste Management is perhaps the most essential house-keeping service required by urban dwellers to maintain their quality of life. In India, this service lags behind, leading to some chaos in the urban sector. Institutional weaknesses, shortages of human and financial resources, improper technology, inadequate coverage, improper collection, transportation, disposal and lack of overall proper planning are associated with the weakness of solid waste management system in most of the cities of India.

4.1 Bhopal City Profile

Bhopal, the capital city of Madhya Pradesh, a province in Central India, is known for its rich natural endowments and the diversity of its natural, physical and cultural resources. It is located in a hilly undulating region (550-600 meter from mean sea level). The hillocks and lakes in the city create favourable conditions for environmental conservation and city management practices because of its gradient. It has a subtropical moderate climate where the temperature ranges between 07 deg Cls (January) to 45 deg Cls (May). The average annual rainfall is between 125 – 150 cm most of them being experienced during July-September.
Bhopal is the second largest city in the State with a population in 2011 of 18,83,381. During 1951-61 the population growth was nearly 120%. In the decade of 1971-81, the establishment of Mandideep industrial area coupled with heavy commercialization, and expansion of Government services further gave impetus to the population, which recorded a phenomenal 74.35% decadal growth. Thereafter also the population continued to grow rapidly before declining to less than 30% during 2001-2011. There is a clear indication that unusually high growth is now stabilizing and the rate will further slowdown in the following decades particularly because the area base has significantly widened. The growth in the population seems to be significantly attributable to mainly natural growth and Migration.

4.2 Present Status of Solid Waste

City dwellers are facing the hazards of improper and inadequate solid waste management. This has crippled the general health and hygiene management of the city. The city requires substantial improvement in the SWM practices prevailing to raise the over-all quality of life in view of the irreversible urbanization.
As per Mehta & Associates the exact quantity and characteristic of waste produce in Bhopal is not known, but the BMC reports that 550T/day of solid waste is generated in the urban area. Most waste dumped on open land or outside the containers. At present municipal waste is crudely dumped at the Bhanpur village trenching ground, at about road and during the rainy season16km from the city. There is no proper access most of the refuse vehicles do not reach the disposal site. Characteristics of Solid Waste in Bhopal were studied through three sample sites from different activity areas by Mehta are as follow:

Table 2. Characteristics of Solid Waste in Bhopal (Mehta & Associates)

S. N	Test	Site – I Jehangirabad (Resi/Com)	Site – II Fatehgarh (Resi)	Site - III Bairagar (Sabji Mandi)
	Physical			
1	Compostable material	28%	63%	72%
2	Paper	2.9%	16%	6%
3	Plastics	2.9%	10%	6%
4	Glass & Ceramics	2.4%	1.2%	Nil
5	Earth, Stones, Bricks	30%	10%	7%
6	Moisture Content	25%	46%	58%
7	Volatile Substances	36%	44%	53%
8	Non Volatile Substances	64%	56%	47%
	Chemical			
9	Carbon Content	26%	27%	29%
10	Total Nitrogen	0.8%	0.65%	0.7%
11	PH	6.0	6.2	6.4%
12	Potassium	0.41%	0.48%	0.68%
13	Phosphorus	0.7%	0.65%	0.45%
14	HCV in Kcal/Kg	1252	1024	821
15	C/N Ratio	32.5	41.5%	41.4

For efficient waste collection management system the city is divided into 14 Zone, the work relating to primary collection of waste has been decentralized at the zone level where is supervised by health officers with the assistance of ward level inspectors/ Daroga, Sanitary super-wiser. The primary collection involves waste disposal by households and commercial and institutional places.
BMC has 77 fleets of vehicles for collecting and transporting waste from collection points to the disposal site. Each of the vehicles is allotted specific area for collection and transportation to Bhanpur site. The collection vehicles attend collection point daily and the other location as per the schedule or as per the directions of Health officers. Waste collected from city

is disposed at Bhanpura trenching ground existing landfill site that is 15 km away from New Bhopal. Almost 230 to 280 trips are made to land fill site by 77 Vehicles ever day. The disposal site also has a waste processing plant which has been commission and run by M.P. Agro state organization installed capacity of Bio fertilizer is 100MT/day of composting.

The Bio Medical Waste generated from Govt. and Private Hospitals and regulated at source and collected in different bags as per BMW rules. BMW wastes are collected in 223 hospitals / Nursing Home and Transported in close vehicles to Private all India Nursing Home Association (Bhopal Incinerators Ltd. Govindpura). The Plant is installed at Govindpura Industrial area Bhopal.

The status of solid waste management in Bhopal municipal area was presented in a workshop which gives very poor sign.

Table 3. Solid Waste Management Indicators

Performance Indicator	Benchmark	Status
Household Level Coverage	100%	5.6
Eff. in Collection of Solid Waste	100%	96.8
Extent of Segregation of MSW	100%	Nil
Extent of MSW Recovered	80%	Nil
Extent of Scientific Disposal of MSW	100%	Nil
Extent of Cost Recovery	100%	6.5
Eff. in Redressal of Customer Complaints	80%	100
Eff. In Collection of SWM Charges	90%	66.4

Source: SLB Results Workshop Bhopal (14th-15th Dec, 2009)

4.3 Solid Waste Management Issues

1) Storage of waste at source is not fully taking place as people prefer to dispose the waste as and where it is generated.
2) Segregation of recyclable wastage is not yet adopted and often found mixed with garbage disposed at different places.
3) The system of door-to-door collection of waste is not sufficient and street sweeping is the main method of waste collection.
4) There are 88 colonies developed by BDA, Housing Board Colony and PWD where cleaning is not done by these sweepers.
5) Transportation of the waste is done through various vehicles like trucks, trolleys, refuse compactors and dumpers etc. No transportation is done on public holidays and Sundays.
6) About 600 MT of SW is generated in the city per day which is collected through street sweeping and from the communal waste storage sites.
7) MP State Agro Development Corporation has setup a compost plant of 120 MT per day capacity on a plot adjoining the landfill site which is sufficient.
8) The city has 75 acre of land for waste disposal which is situated 16 Kms away from the city. The waste is disposed off at the landfill site in orthodox method of dumping. To transport waste from different generation point to the landfill site need environmental consideration.

5. Suggestions and Conclusion

Waste can be defined in different manners based on various perceptions. Municipal solid waste includes different sources of generation such as residential, commercial, institutional, industrial, and municipal public area. According to land use and human activity, Bhopal municipal area can also be classified in these fundamental classes. The composition of waste varies depending on its source. Table 4 shows the common municipal solid waste generation source with its expected composition type.

Table 4. Waste generation sources and composition

Generation sources	Composition types
Residential	Food scraps, food packaging, cans, bottles, newspapers, clothing, yard waste, old appliances
Commercial	Office paper, corrugated boxes, food waste, disposable tableware, paper napkins, yard waste, wood pallets, construction and demolition waste
Institutional	Office paper, corrugated boxes, cafeteria waste, restroom waste, classroom waste, yard waste
Industrial	Office paper, corrugated boxes, wood pallets, cafeteria waste
Municipal	Litter, street sweepings, abandoned automobiles, e-waste, some construction and demolition debris

A list of all its waste type with their generation source might be prepared. These wastes might be classified into organic and inorganic matters. The organic particles might be processed for manure. Hazardous waste should be segregated form inorganic wastes and disposed separately. All inorganic waste might be processed with 3R (Reduce, Reuse and Recycle). JNNURM toolkit recommends approach to effective waste management prioritizes waste minimization and recycling against other techniques. It states that waste management systems must be designed based on actual field conditions and after due considerations of the feasibility. The suggested approaches to 3R to different Waste types are as follow which might help to achieve a city of 'Zero Waste'.

Table 5. Approach to 3R to different Waste Types

Waste Type	3R Solution to Waste Type
General House Hold Waste (Including Kitchen/Food Waste)	Waste which includes paper, plastics, wood, ceramics etc. in mixed form and Kitchen Waste which is primarily food and vegetable peel waste. Towards reduction of kitchen/food waste public awareness towards reduction of food waste, segregation for easy composting is required. Also decentralized composting initiatives must be propagated. Kitchen gardens to be propagated by authorities. As a reduction measure for '*General House Hold Waste'*, public awareness towards waste reduction through recycling of their house hold waste must be imparted. Waste recycling for paper, cardboards, plastics etc are informal activities under MSW management. Such activities needed to be formalized under the urban local body or mobilizing Non Governmental Organization (NGO). Some household waste have hazardous characteristics (such as dry paints, pesticide bottles etc.) which must be separated out from the main MSW stream. Disposal of such waste must be done as per Hazardous Waste Management Rules. Waste Batteries must be disposed as per Batteries Rules 2001. Other house hold hazardous waste must be sorted at source and disposed according to Hazardous Waste Management Rules.
Road Sweeping Waste	Waste contains dirt and silt along with recoverable such as paper and plastics etc. Efforts to be made to avoid waste disposal on roads and streets as public awareness measure which will also improve civic sense vis-a-vis aesthetics of the city. Recoverable material such as paper, plastics, cardboards etc. to be collected and recycled during treatment.
Construction Waste	As building demolition is the main component of this waste type, waste recycling, by screening out useful material 'fit for reuse' must be propagated. The waste can be used as an inert fill material for low-lying areas and landscaping, processed Construction & Demolition (C&D) waste can be used for road and embankment construction, finer grade can be moulded into blocks and slabs with appropriate binder, the finer grade can also be used as daily cover for (Sanitary Landfill) SLF / closure of SLF
Drain Silt/Waste	The cause to drain silt is mostly inefficiently designed storm water systems and 'negligence' in people while disposing garbage. As a reduction strategy these two shortcomings must be targeted. Drain silt having some portions of organic matter is best disposed into a sanitary landfill.
Market and Commercial Waste	The waste category mostly forms paper, plastics, cardboards, packing material, rubber etc. As a measure to reduce, the implementing agencies must discourage use of plastic products as they only aggravate sanitation situation (being not easily decomposing). Further initiatives to recycle waste by proper segregation of these materials must be propagated. Formalizing waste recycling at Material Recovery Units (MRF, as found in many towns in India, such as Kadappa town in A.P state) must be adopted as a waste management measure
Institutional Waste	Institutional waste includes organic waste (small quantities), large amounts of paper, plastics and rejected E waste and also hazardous house hold waste is typically found. Initiatives such as printing paper on both sides, use of reused paper, and propagating minimum use of plastics must be taken up. Institutions can play in a major role in managing E-waste, by following Extended Producers Responsibility (EPR) principle, which refers to management of waste by the producers. Hence institutions must create arrangements with their equipment providers to help manage their E-waste, such as computers, printer cartridge, etc.
Sludge from STPs and ETPs	Sewage Treatment plants generate sludge as solid waste. Sludge mixed with other MSW helps sped up composting process. Sludge must be dried before disposal.
Horticultural Waste	This waste type forms excellent compost after bio decomposition. Hence such waste type must be used for composting rather indiscriminate disposal.
Waste from Slaughter Houses and Dead Animals	Dead animals should be incinerated in a scientific manner. The Manual on MSW management and handling provides guidelines towards management of such waste. Slaughter house waste is a combination of following types of waste which included manure from stork yards, blood and hair from killing floors, paunch manure and liquor flesh, grease blood, etc. The waste water from slaughter house is highly polluted and, should not be allowed to flow into the municipal drain system without pre-treatment meeting sewage standards as per the Bureau of Indian Standards (BIS) The Manual on MSW Management and Handling proposes that these types of waste are required to be disposed by adopting methods like rendering /controlled incineration/burial/composting/anaerobic digestion etc. Slaughter house waste could also be explored for power generation due to high organic content in this waste, which help faster decomposition, leading to biogas generation. Central Pollution Control Board (CPCB) has brought out "Draft Guidelines for Sanitation in Slaughter Houses" during August, 1998. Plant in Vijayawada, with 150 KW capacity using vegetable market & slaughter house waste. The plant used 16 TPD of segregated MSW and 4 TPD of slaughter house waste for electricity generation using 'biomethnation process'.

Bhopal has poor collection efficiency as only 60% of the solid waste generated is collected due to poor primary collection and lack of synchronization of collection, storage and transport of solid waste. Currently no waste segregation is done by BMC and only 20% of wastes are processed to composting process. Still traditional method of treatment of dumping at landfill site is used and there is no sufficient Biomedical waste Disposal Facility. To maximize efficiency and effectiveness of municipal management system, it is necessary to tackle the problem systematically by appreciating in a city

specific manner the different dimensions of SWM and devise cost effective systems which would be viable in the available socio-economic and politico-environmental setting.

6. The Road Ahead

Raghav Chandra, former Housing Commissioner, Government of Madhya Pradesh, Bhopal states that efforts are being made that solid waste generated at different sites should not be allowed to be disposed anywhere and everywhere. Out of the waste generated recyclable waste should be stored separately and that primary collection system should ensure either doorstep collection or community based collection and this collection system should synchronized with communal waste storage facility and transportation of waste in such a manner that multiple handling of waste is avoided. Decentralization of administration adequate delegation of administrative and financial powers, training of staff, people's participation, levy of penalties and health care measure are being undertaken to make the SWM system effective and efficient. Following further specific measures are being planned for improving and modernizing the Solid Waste Management Practices in the city:-

Storage of Waste at Source

- Keep the street and public places clean is the responsibility of all. This motive can be achieved only with people's participation and co-operation.
- No Waste shall be thrown on the Streets, Footpaths, Open spaces, Drains or Water Bodies.
- Waste shall be stored at sources of waste generation designated bins.
- Hazardous household waste should be kept separately from the above two streams of waste.

Primary Collection of Waste

- Domestic, trade and institutional food/bio degradable waste are to be collected on a daily basis.
- Recyclable waste and non-biodegradable waste other than toxic and hazardous waste are to be collected at regular intervals from the source of waste generation.
- Hazardous and toxic was are be deposited by the waste producer at specified places and not elsewhere.

Segregation of recyclable / Non Biodegradable Waste

- The BMC has directed households, shops, establishments not to mix recyclable waste with domestic waste.
- These two categories of waste are to be kept in a separate bin or bag at the source of waste generation and collection itself.

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References and Bibliography

Census of India. (2011). Provisional Population Totals: India: Census 2011. Retrieved November 14, 2013, from Census of India 2011: http://censusindia.gov.in/2011-prov-results/indiaatglance.html

Department of Economic Affairs, MoF, GoI. (2009). Position paper on The Solid Waste Management Sector in India.

Department of Environmental Conservation. (2013). What is Solid Waste. Retrieved November 12, 2013, from New York State Department of Environmental Conservation: http://www.dec.ny.gov/chemical/8732.html

Kaushal, R. K., Varghese, G. K., & Chabukdharan, M. (2012). Municipal Solid Waste Manageemnt in India-Current State and Future Challenges: A Review. International Journal of Engineering Science and Technology , 4, 1473 - 1489.

Kidani, A. B. (2013, November 9). Sudan Vision Daily. Retrieved November 15, 2013, from Sudan Vision An Independent Daily: http://news.sudanvisiondaily.com/details.html?rsnpid=228757

Kurian, J., Esakku, S., Nagendran, R., & Visvanathan, C. (2007). A Decision Making Tool for Dumpsite Rehabilitation in Developing Countries. Sardinia 2005, Tenth International Waste Management and Landfill Symposium. Cagliari: CISA, Environmental Sanitary Engineering Centre, Italy.

Mehta & Associates. Bhopal City Development Plan. Bhopal: Bhopal Municipal Corporation.

Ministry of Urban Development. (2012). Toolkit for Solid Waste Management - Jawaharlal Nehru National Urban Renewal Mission.

Public Health. (n.d.). What is Solid Waste. Retrieved November 15, 2013, from Mason County: http://www.co.mason.wa.us/health/environmental/solid_waste/what_is_solid_waste.php

Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R. C. (2008). Municipal Solid waste management in India cities - A review. ELSEVIER , 459-467.

Sharholy, M., Ahmad, K., Vaishya, R. C., & Gupta, R. D. (2007). Municipal solid waste characteristics and management in Allahabad, India. ELSEVIER , 490-496.

Smart Ranger. (2009). What is Solid Waste? Retrieved October 27, 2013, from Smart Range: http://www.smartranger.net/index.cfm?&menuid=3

UNEP. (2009). Developing Integrated Solid Waste Management Plan - Training Manual (Vol. 2). Osaka, Japan: United Nation Environment Programme.

Zaman, A. U., & Lehmann, S. (2011). Challenges and Opportunities in Transforming a City into a "Zero Waste City". Challenges , 73 -93.

Zhu, D., Asnani, P. U., Zurbrugg, C., Anapolsky, S., & Mani, S. (2008). Improving Municipal Solid Waste Management in India - A Sourcebook for Policy Maker and Practitioners. Washington, D.C.: World Bank.