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Projection and Quantification of Municipal Solid Waste Management in Bhopal city M.P. India

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Abstract
This research work has been conducted to define and understand the current problems of waste disposal quantification and its management in Bhopal city. The study focuses the technical aspects of the solid waste management and its interpretation of collected data like waste quantification and projection of waste generation in future trends.

The study summarized that 756 tons of garbage generated daily in the city, where 195.04 tons are uncollected which is 25.80% of total waste and remaining 74.20% of waste is collected by the Bhopal Municipal Corporation. The status shown per capita per day uncollected waste quantity is 142.01 grams in 2010 which is simultaneously increasing in grams 147, 152, 158 in 2011, 2012 and 2013 respectively. In the year 2030 it goes to be 1129.615 grams/day/person and uncollected waste will be 291.44 gram/person/day, which need proper attention and management. These wastes are, however never collected but are dumped or burnt locally resulted causing air pollution.

Keywords: *Municipal Solid Waste Management, waste quantification, Population Projection*

1. Introduction

Waste management is an essential task which has important consequences for public health. It is a complex job which requires appropriate organizational capacity and cooperation between numerous stakeholders in the private and public sectors. Although it is essential to public health and environmental protection, municipal solid waste management in most cities of developing countries as well as cities is highly unsatisfactory (Schübeler Peter, 1996). Many cities and towns are overburden by the increase in the volume of waste needs to be managed effectively. The city of Bhopal is not exception to this regard. The present situation of direct dumping of waste without proper inspection and separation leaves posing a serious impact of environment and causing a tremendous growth in health related problems. "Domestic, industrial and other wastes, whether they are low or medium level wastes, causing environmental pollution and has become perennial problems for mankind." (Ramasamy et al., 2003).

Any material that is thrown away or discarded as useless and unwanted is considered waste. At first glance, the disposal of solid waste may appear to be a very simple and commonplace problem. Solid waste can harbor rodents and insects, which may act as vectors of infectious diseases such as typhoid, plague and dysentery. Municipal solid waste (MSW) is considered non-hazardous, but certain types of commercial and industrial waste are poisonous, explosive or otherwise vary dangerous and it can causes direct harm to people and environment if not disposed properly.

There are various types of solid waste management problems and practices in a number of Indian cities. The number of Class I cities with population exceeding 1, 00,000 has increased from 2012 to 300 during 1981 to 1991 (CPHEEO, 2000). In 1961 about 79 million persons lived in urban areas of the country; by 1991, their number had increased to over 217 million, registering an increase of over 250 per cent in the last three decades. Almost all population projections indicate that India will enter the 21st century with an urban population of about 300 million, which will further increase to over 400 million in the year 2011 and 553 million in the year 2021. A solid waste from Indian cities contains high proportion of organic matter and also has high moisture content. The organic content attracts flies and rodents as well as high temperature and humidity favor rapid bacterial growth and decomposition of the waste that cause foul smell.

2. Material and Methods

Bhopal is a heart of Madhya Pradesh located at Latitude 23o15' N and Longitude 77o24'E. The present investigation it has been taken care to pin pointly select the study zones to represents the features of the entire Bhopal municipal area. The area of BMC limit reached to 71.23 Sq. Km. by 1975 and now the area of Bhopal city occupied 285 sq.km. The district Population of Bhopal is 18, 43,510 which are divided into 9, 72,649 man and 8, 70,861 women, and town population is 14, 37,324 (census 2001). The rate of the population growth is high due to the various region and purposes.

The primary data were collected through field visit, discussion with community using Questionnaire method. An existing questionnaire was prepared for surveying the household in residential area, market and commercial areas. Various solid waste and waste generation related information were collected by interviewing of various officers and workers of the Bhopal Municipal Corporation such as Health Officers (HO), Assistant Health Officers (AHO) Sanitary Inspector (SI), BMC workers (Jamadar, Safai Karmachari, Sweeper, sanitary worker) through questioner/interview method. The secondary data were collected from different sources of Bhopal Municipal Corporation (BMC), and different wards and Zones. The other related to the study data was gathered by the related govt. department and related organization has provided the essential and valuable information and facilities associated to this research work.

2.1 Sampling of the study area:

Bhopal Municipal Corporation has divided in 14 zones and each zone is further divided into different wards, which constituting 66 wards. In point of that case, the study area is very broad hence sampling is mandatory. The basis of sampling, zone population, zone area, ward distribution and waste generation have been considered. The sampled zones represent more than 10% of the total BMC zones (14 Zones) whereas the sampled wards represent approximately 10% of the total 66 BMC wards. For the experimental purpose the selected area belongs to Zone No. 6, which includes four wards namely (Ward no. 28, 29, 30, 31) and Zone 12 consisting of two wards (ward 65 and 66). The total population of the zone 6 is 99,496 and area is 22.89 sq km whereas zone no.12 has a total population of 1, 03,788 and area of 23.54 sq km. An interesting fact is that zone 12 is situated near the BMC dumping site, Bhanpur and zone 6 present both commercial and residential area.

2.2 Waste Sample Collections

This is a typical work in the field because MSW characteristics in heterogeneous nature thus necessary to take samples from different dust bins. The following techniques were involved for taking waste samples.

Quartering technique:

About 100 kg. of sample is collected from different dustbins, mixed thoroughly and divided into four equal parts. Out of four parts two diagonally opposite parts are mixed and remaining two diagonally opposite parts are rejected. This method is repeated till the final mass is about 12.5kg. The method is termed quartering technique. Various constituents are segregated from the final mass and weighed. The amounts of ingredients present in the waste are expressed in percentage. Physical analysis is done to assess the amount of various ingredients present in the waste. The waste collected from different households is mixed to prepare a composite sample. The selection of household is randomly done for each group of house type. Waste is collected from these households regularly and weighed. Knowing the weighed quantity number of residents of the house selected for sampling and total population of each zone, quantity of wastes in each zone as well as total quantity of waste generated in the city could be estimated. Number of sampling points is dependent upon area and size of the population of the locality. Samples are also collected from different dustbins. The weighing of waste vehicle is also very helpful for the city waste quantification. The city waste loaded vehicle goes towards the weighbridge, weighs the loaded waste and also the number of trips of these vehicles are recorded. This data shows the quantity of waste generated in different zones, as different vehicles are allotted in different zones and thereby quantity of waste from each zone is estimated from the weighment data and trips of the vehicle recorded. This exercise is carried through the month as well as year. Therefore the total average quantity of waste is estimated by summing up the data of all zones.

2.3 Population Projection Method:

Population is a very important parameter to study of waste generation and management. The increasing population simultaneously increases waste generation in the city. The growth of population is depending upon the available natural resources in the area. Each decade govt. surveyed population of the city which is called census and the last census was done in 2001 and the new census will be on 2011, hence the gap between the years, projection is required which is giving rough figure on the basis of past growth rate of the population. Projections are conditional statements about the future. Projections are based on the assumption that the past trends will continue to operate in the future. In general, population projections are treated as predictions and are never to be termed as final population. In the study area is obligatory to projected year wise population of the city which can be help to access of the current and future waste generation. The population projection having various methods and this study used the annual population growth rate was done. This method found that the annual growth rate of population is very appropriate for projected population. A percent growth rate (or sometimes referred to as percent change, growth rate, or rate of change) is a useful indicator to look at how much a population is growing or declining in a particular area. It is also useful when comparing the growth or decline of populations in two different areas or regions. Any number from one time and any number from another time can be put into the calculation to determine growth rate (Paul McDaniel 2009). The rate of change (percent

change, growth rate) from one period to another is calculated as follows:

$$\% \text{ change} = \frac{V_{present} - V_{past}}{V_{past}} \times 100$$

Vpresent = present or future value
V past = past or present value
Another way of expressing the equation for growth rate or percent change is:
Percent change = (V present-V past)/V past X100
In this formula:
To further calculate an annual percentage rate of change, divide the percent change arrived at in step two by N. N represents the number of years between the two values used in step 2
Example to calculate growth rate or percent change: A Bhopal city has a population of 1063662 in 1991 and a population of 1423602 in 2001. To find the growth rate of the population in this city:

Growth Rate = (1436822- 1051729) / 1051729 X 100
Growth Rate = 36.61 percent
Average Annual Growth Rate = 36.61/ 10 years
Average Annual Growth Rate = 3.66 %/year
It is calculated by the population projection calculator, Enter a Starting Population size (digits only, no commas) for a given Starting Year. Growth Rate is a percentage expressed as a fraction (i.e. 1% growth is 0.01, 10% is 0.1, etc.). If Show Sub-Totals is checked, then the population size for every year up to Ending Year will be displayed. This calculator attempts to show the power of human numbers to grow exponentially (www.metamorphosisalpha.com/ias/population.php). The average growth rate for the Bhopal city is estimated as 0.036% per year. Considering this situation the from the population calculator where the growth rate of Bhopal is 0.036% following projection on the basis of growth rate are made in table 1.1. Development of Bhopal looks place gradually with the increase of education facilities, industries and employment opportunities. Bhopal is now an important education hub of the state.

3. Tables, Figures and Equations

3.1 Tables and Figures

Table: 1.1 Population projection of study area by growth rate

S.No.	Year	Population
1.	2001	1436822
2.	2002	14,89,409
3.	2003	15,43,922
4.	2004	16,00,429
5.	2005	16,59,005
6.	2006	17,19,724
7.	2007	17,82,666
8.	2008	18,47,912
9.	2009	19,15,546
10.	2010	19,85,655
11.	**2011**	**20,58,330**
12.	**2012**	**21,33,664**
13.	2013	22,11,757
14.	2014	22,92,707
15.	2015	23,76,620
16.	2030	40,75,002

4. Conclusions

Information on the subject of the weight, volume, and composition of municipal solid waste is necessary for the proper planning, design and operation of collection and disposal facilities. To have an idea of waste generated every day a detailed random survey was conducted in zone 6 and zone 12 wards. Waste quantification sampling in zone 6 and zone 12 was done. The collected waste from different waste collecting units was mixed to prepare a composite sample and then segregated and estimate following different waste constituents.

4.1 Waste composition of Zone 6: Table 1.2 and fig 1.1 fig 1.2 shown the waste composition of zone 6 and zone 12.

Table 1.2 Physical analysis of household waste of zone 6			
S. No.	**Type of Waste**	**Wet weight in g./house**	**Dry weight in g.**
1	Polythene	110	109
2	Paper	130	128
3	Organic waste	680	610
4	Dust, swept	415	412
5	Glass	430	430
6	Metal	600	600
7	Other	425	422
	Total	**2790**	**2711**
Physical analysis of household waste of zone 12			
1	Polythene	90	89
2	Paper	98	97
3	Organic waste	530	510
4	Dust, swept	400	397
5	Glass	420	420

6	Metal	530	530
7	Other	450	448
	Total	**2518**	**2491**

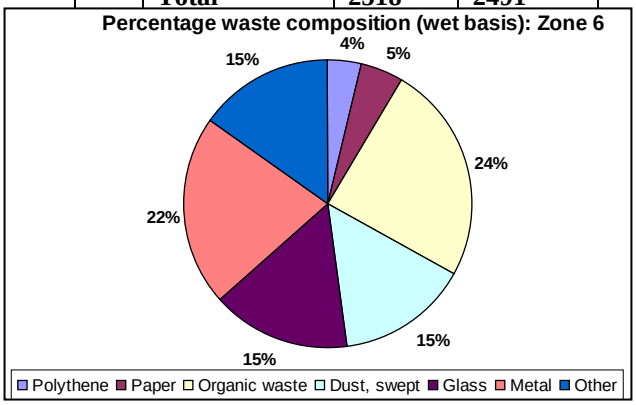

Fig. 1 Percentage waste composition Zone 6

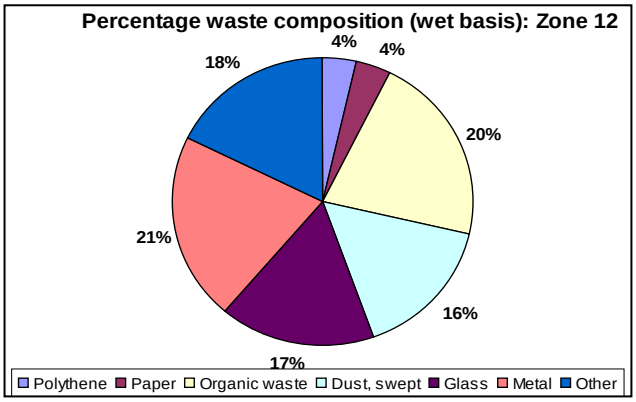

Fig. 1 Percentage waste composition Zone 12

3.3 Annual waste generation of Bhopal Municipal Corporation:

To estimate the overall waste generation an exercise has done. Table 1.3 shown the waste comes into the dumping site Bhanpur per month in 2009. The waste generation assessment is based on the waste collected at the dumping site month wise. The computation further gives the waste collection for all the twelve months during the year 2009.

Table: 1.3 Waste collections by BMC in 2009

S. No.	Month	Waste generation (tones)
1.	January	23872.505
2.	February	21990.355
3.	March	21206.07
4.	April	22553.777
5.	May	23935.62
6.	June	21772.44
7.	July	22977.724
8.	August	23083.26
9.	September	23585.07
10.	October	22599.515
11.	November	21884.825
12.	December	22890.74
	Total	**272351.901**

Solid waste estimation of BMC area (from Table 1.3):

Annual waste collected by Bhopal Municipal Corporation in 2009	272351.90tonne (272351900 kg)
Monthly waste collected by BMC 272351900 / 12	22695991.6 kg
Per day waste collected by BMC 22695991.6 / 30	756533.05 kg /day
Per capita waste collected by BMC 756533.05/ population 2009	0.394 kg/capita/day (394 grm/person/day)

Solid waste estimation by field survey by sampling method (from Table 1.2):

Zone 6 waste generation/household (hh) /day	2790grm/day/hh
Zone 12 waste generation/household/ day	2518grm/day/hh
Average value	5308/2 2654 gram/HH/day
During the sampling time, it was found that one family have 5 persons and accordingly	2654/5
Waste generation/person/day	531 gram/person/day

Per person/day waste generation estimated based on the data of BMC includes collected waste only while estimation based on field survey includes both collected as well as uncollected. Therefore, based on both estimation, uncollected waste in the BMC area can be calculated. The estimation of waste generation of Zone 6 and Zone 12 has been taken as representative of whole BMC area as these zones have the mixed types of waste generation sources.

Calculation of uncollected waste is as followed:

Waste generation (by field survey and analysis) – Waste collected by the BMC

= 531 - 394 grm/person/day

Uncollected waste = (137) gram/person/day uncollected waste

This uncollected waste value is about 25.80% of the total waste generated and the 74.20% waste is collected by the BMC. By visualization of uncollected waste, it seems that magnitude of problem is very high. Although some organic waste is given to eat by the animals in situ, even though, it is a serious problem which needs a systematic management. In the year 2030 projected waste quantity will be 1129.615 grams/day/person where uncollected waste is 291.44 gram/person/day, which shows need of its collection, transportation, disposal, and land filling hence its management, is very important task to the BMC. The

reduction of waste is also a very important task waste minimization which helps the directly minimize the waste load into the dumping site. As per the stated in schedule II of the Municipal Solid Waste Management and Handling Rule (2000) has listed collection of MSW with emphasis on segregation at source and door to door collection.

In addition to municipal workers, the rag pickers (Tripathi D.K. *et.al*, 2010) those operate informally for long hours rummaging through waste also suffer from various occupational health diseases like respiratory illnesses from ingesting particulates and bio-aerosols, infections from direct contact with contaminated material, puncture wounds leading to tetanus, hepatitis and HIV infection and headaches and nausea. Now a day backyard contains hazardous waste like batteries, plastic bags and other plastic items. Burning of all these items at low temperature produces toxic fumes. It cause nuisance in the surrounding.

In Bhopal, segregation, collection, storage, transportation and disposal of solid waste are unscientific and disorganized except some wards and zones wherever private waste collectors are working. Unscientific management of wastes on the outskirts of town has created overflowing trenching sites, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. Burning of waste leads to a loss in huge revenues to the government in addition to air pollution. Dumping of solid wastes in the open ground could create aesthetic problems as the beauty of a place is destroyed. The present trenching ground Bhanpur is very ugly and foul effect creates in the surrounding one k.m. periphery of the area and pollutes the air environment. The situation is more critical in rainy and summer seasons. The garbage forms a source of food for rats, flies, mosquitoes and the like. Hence typhoid, plague, dysentery, diarrhea epidemics could occur. Toxic hazardous substances in the wastes would be harmful to human and animal health. There have an opportunity to utilize the waste product in energy production. The increasing plastic, polythene is send to the cement kilns for energy production. It will also utilize through various product development by recycle and recovery.

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