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Solid waste management in Bhopal (India): present and future challenges

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Abstract

The paper deals with some aspects of waste management, such as the current status of waste collection, transport and disposal in Bhopal, will be illustrated. Also, current situation will be evaluated, and its problems will be identified. Presently, daily amount of Municipal solid waste generated in Bhopal was about 0.45kg per person. Present and future requirement of container were calculated and discussed based on assumption of population, different solid generation rate (0.3-0.7 kg/ cap/day) and density (300-400 kg/m^3). It was found that required container was more when density was assumed as 300 kg/m^3, whereas less container was required as assumed density was 400 kg/m^3. Some of physical-chemical characterization of solid waste were calculated and discussed. Average value of density and lower and higher calorific value were found to be 290 kg/m^3, 2193 kcal/kg and 2376 kcal/kg respectively. Choice of disposal method should be based on the nature of the waste. Based on the sample characterization of solid waste generated in Bhopal Municipal Area, biodegradable waste generation was 370 metric tons/ day, whereas non-biodegradable waste were 430 metric tons/day. The biodegradable part of the waste, if segregated at source, can be treated by composting. Composting of waste yields a soil conditioner, which can be used for farming and gardening purposes. The site should be fenced to restrict unauthorized entry and surrounded by open drains to collect surface run-off from the disposal site. The sanitary landfill site should have proper access roads for the container carriers, to avoid accessibility problems during the monsoon.

Key words: Bhopal, Solid waste, Management, Container, Population.

1 Introduction

In population and change in life style in India have dramatic increase in Municipal solid waste (MSW). MSW includes both domestic and commerical waste account for relatively small part of the total solid waste stream in developed countries. Municipal solid waste management was generally a neglected issue in the country until the Municiapl Solid Waste[1] were promulgated. Indian cities generate an estimated 0.115 million metric tones of waste per day and 42 million metric tones annually. The per capital waste generation ranges between 0.2 and 0.6 kg per day in the Indian cities that is lower than that in developed countries. The organic matter in solid waste in developing countries in much higher than that in the waste in developed countries. Accumulation of a large amount of waste may create several problems to inhabiting populations. During the last three decades, National Environmental Engineering Research Institute has carried out studies in more than 50 cities and towns in India. Characterization of MSW indicated that the waste consists of 30-45% organic matter, 6-10% recyalables, and the rest as inert matter. Its requires application of some effective strategies for proper disposal of MSW[2].

1.1 General description of existing solid waste management (SWM) :

Bhopal municipal corporation (BMC) is responsible for SWM of the entire Bhopal city. BMC collects waste generated from house-holds, Institutions, Hotels, Markets, Shops, Commercial establishment *etc*; from all 66 wards; BMC transport and dispose these waste to Bhanpura dumping site. Due to limited financial resources, BMC found it difficult to give special emphasis on collection, transportation and disposal of solid wastes from these wards and thus failed to prevent pollution and health hazards due to inadequate financial resources, man-powers, equipment and trained personnel.

Based on the system of sampling has explained. The current waste generation is 298.30 g/cap/day. The quantity of waste being collected and transported to Bhanpura dumping site is around 350 to 360 MT/day based on the 7 days (from 18-12-2009 to 25-12-2009) record of weighing of waste coming to Bhanpura dumping site. Average quantity of waste disposal per day to Bhanpura dumping site was 344.51 MT/day shown in Table 1. There is no primary collection system for the MSW in Bhopal city. Except in some housing complex generally the residents deposit their household waste on the sides of the road, in the adjacent area or simply thrown on the open drains, public places and open areas, which subsequently gets collected by the municipal sweepers. Throwing of solid waste into nearby drains by local residents, results in chocking of sewerage/storm water drains causing flooding in monsoon season. In some housing complexes primary collection is done by private agencies and the waste so collected is deposited to nearby collection container.

Presently around 1380 Safai Karamchari (municipal sweepers) and 400 sweepers on daily wages are involved in street sweeping and collection of solid wastes from various locations of the city. There are about 2628 collection points in the city where waste accumulates. BMC is carrying out, maximum transportation with its own fleet of equipments. Presently BMC is using dumper placer, refuge

collectors, dumpers, tractor trailer, conventional truck and mini truck for transportation of solids waste. *It is observed that carrying waste vehicles are not covered, while transporting the waste.* There is one centralized garbage located at Mata Mandir near Awantibai Chauraha and it is operated by BMC.

Waste Disposal in Bhopal is practiced by dumping in low lying areas in majority of the urban centers. Currently the solid waste is disposed unscientifically by open dumping at Bhanpura village disposal site. Bhanpura disposal site is located within the BMC limits and is spread over an area of 57.80 hectares. This site is in use for last 25 years. The facilities provided by BMC at this site are electronic weigh bridge cum record room (capacity 30 tons) and washing areas for vehicles. Slaughtering of dead animals is also carried out at the site. Bhanpura site has a Bio- fertilizer plant of capacity 100 MT/day. This plant was set up around 10 years ago by M/s. MP Agro Fertilizer Corporation Ltd. Though the plant is in operation its capacity is substantially underutilized. There is no separate Solid Waste Management Department in the BMC. Health Officer is in-charge of SWM activities. Health Officers is assisted by 2 assistant Health Officers, 4 Chief Sanitory Inspectors, Jamadars and 1780 Sweepers including daily wage workers carry out this activity. Bhopal city has been divided into 14 SWM zones for administrative purpose. The major issues related to the financial aspects of BMC are: Inadequate resources, Absence of national level policy and guidelines for allocation of resources for SWM, Poor community participation that increases public spending and lack of private sector participation. There is no primary collection system for the Municipal Solid Waste (MSW) in Bhopal city. The residents deposit their household waste on the sides of the roads, in adjacent area or simply thrown on the open drains, public places and open areas, which subsequently gets collected by the Municipal sweepers. At present BMC removes solid wastes from all 66 wards.

The sweeping practice is on the basis of three tier system. One sweeper sweeps the street, roads and heaps it on the road/street side and second sweeper collects the waste into handcart and carries the waste to collection point. Rag-pickers are also presently involved in day to day segregation of recyclable waste. There are about 2628 collection points in the city where waste accumulates, out of which 1490 are open spots (including kachara ghar), 750 No have 1.0 m^3 containers including 100 containers of 1.0 m^3 recently purchased by BMC, 300 no R.C.C. Rings 88 no have 4.5 m^3 containers and around 366 traditions at handcarts are presently being used for collection of solid wastes (BMC, 2009). These hand carts are being used mainly to collects wastes from street sweeping activities. In residential colonies like Arera colony, Akriti Gardens, Koh-e-Fiza, Raj Homes, Minar Garden, Siddharth Enclave Woodland Apartment, Sagar Garden Home, Fortune City etc. Private sweepers are engaged for collection of solid wastes from individual house- holds. The residents of these colonies engage such sweepers for removal of solid wastes generated within their premises. The private sweepers collects solid waste from house to house and deposit the same to the nearest collection points. Solid waste generated from the markets and commercial activities are either put to the adjacent community containers wherever available or

thrown to the nearby open spaces, drains and streets. The shops, markets and other commercial establishments normally start business after 9.30—10.00am. These timing do not synchronize with the work schedule of the sweepers as by this time most of the collection procedure is over after collection of solid waste from main streets and roads. Therefore the solid wastes from these sources are thrown on road side, drains and nearby open areas. Hence the solid waste litters on roads and streets in these areas for whole day before sweeper cleans it on the next day. The city does not appear clean. The same is true in the case of hotels, restaurants and vegetable markets also.

From defense area, Railway colonies, BHEL colonies, Airport the collection of solid waste is being done by their own staff. Solid waste generated from these localities is deposited in the adjacent collection point which in turn is removed by the BMC. From cinema halls, parks, gardens, bus stand, railway station, clubs, stadium, the collection of solid waste is being done by their own staff. Solid waste generated from these localities is deposited in the adjacent collection points which in turn are removed by the BMC. The waste is not segregated at source. The construction and demolition waste is generated mainly by new construction work, repair work maintenance and reconstruction activities. It contains bricks bats unused sand, broken tiles, useless wood and steel scrap etc. The storage of this waste at the time of its generation and its disposal is totally neglected in the city. Generally people throw the construction waste just outside their house/ shops/ establishments, along road side and a few in low lying areas. This is creating nuisance and obstruction to traffic. There is no figure available from BMC for quantity of waste generation from this activity. There is no segregation of biomedical waste generated from hospitals, medical clinics, dispensaries and other medical establishments except in few hospitals where segregation at bio medical waste at sources is done. There is an incinerator in Govindpura, for disposal of biomedical wastes generated from various hospitals in the city. Another incinerator exists in Hamidia Hospital for in-house biomedical waste disposal. Remaining BMC generated in the city is mixed up with MSW and disposed off at existing dumping sites. So lot of changes are required for improvement of municipal solid management in Bhopal and this paper deals with fundamental calculation of container required for present and future and also supported by the some of the physic-chemical analysis values of solid waste at different wards.

2. Materials and Methods

2.1. Sample collection and segregation :

MSW samples were collected for five working days (excluding Mondays) from each of four different community bins and their locations are shown in Table 1. This means a total of 20 samples were segregated on-site. Each time, the municipality labourers mixed the bin contents and removed 25 kg of the bulk mixed sample. This sample was then segregated manually into different physical components like paper, plastics, rubber, leather, glass, metals, textiles and polyethylene bags. Each of these recyclable materials was weighed to determine its fraction in the total solid waste sample collected. The remaining material was a uniform mixture of organic material along with soil, mud, sand and other inert materials that were not manually separable, and is termed mixed

residue in this paper. 2 kg of this mix from each sample was collected in polyethylene bags, brought to the laboratory, and analyzed for moisture content immediately. The remaining samples were stored and analyzed for other important parameters and these are described next.

2.2. Laboratory sample analyses :

Samples of 100 g were taken in triplicate, and dried to a constant weight in an oven at 105 ^{o}C for 24 h, cooled in a desiccator and the difference in weight recorded. Moisture content is the percent sample weight lost in drying. Calorific value was determined in the laboratory using a bomb calorimeter, which provides the gross calorific value at constant volume. Since there are no standard methods for analyzing solids in MSW samples, the different fractions of solids in thewaste sampleswere analyzed based on the same methods recommended for river and lake sediment samples and sludge samples, *i.e.*, solid and semi-solid samples from water and wastewater treatment[3]. Total solids are defined as the solids left in the sample after it has been dried to a constant weight at 103–105 ^{0}C. When total solids are ignited in a muffle furnace at 550±50 ^{0}C, the fraction of solids remaining is defined as fixed solids and the fraction lost during ignition is termed volatile solids. The solid waste sample was pulverized after air-drying it to pass a 0.42 mm sieve. The method used to determine organic C content of the waste sample was the same as that used to measure soil organic C content. The COD for the samplewasmeasured as stated previously. Potassium hydrogen phthalate, which is used as the standard for COD measurements, was used to estimate the organic C content of the waste sample. Therefore, the organic C content is in equivalents of potassium hydrogen phthalate.

3. Results and Discussion

3.1. Sampling, Physical and Chemical Characteristics of Different solid waste :

The samples were collected from different locations such as Residential areas (HIG, MIG, LIG and EWS), commercial area, fruit and vegetable markets, weekly market, slaughter house, fish and meat market, hotels, restaurant, garden, hospitals and nursing homes, industries and Bhanpura dumping ground. The samples were collected for 7 days (from 24.05.2009 to 31.05.2009) in a row from two to four sources in each category. For each source samples were collected from three waste generating points. While collecting the samples, family size and their address were noted in data sheet. Samples collected everyday was packed in poly bags and were sent to laboratory for analysis. After weighing each sample again accurately in laboratory, composite samples of each category were prepared for physical and chemical analysis.

The density of solid waste is about 300 kg/m^3 from residential areas, about 400 kg/m^3 from hotels and nearly 285 kg/m^3 from vegetable and fruit market. This density is at the source of generation. If Bhopal is assumed to have a per capita solid waste generation of 400 g/capita-day, and an estimated current population was shown in Table 2. But density of solid waste generated is high, ranging from 500 to 700 kg/m^3. Hence, compaction of waste

is unnecessary during transportation. A summary of these results is provided in Table 2-3. It is clear fromthese data that the 0.40 kg/capita-day generation of solid waste in Bhopal municipality is much less than in other cities in India or other countries. This is attributable to the lower living standards of low-income groups since generation rates are generally dependent on income levels[4].

Bhopal municipality collects solid waste on a daily basis except Sundays and national holidays. Community waste (residential and commercial establishments) is collected by door-to-door collection or deposited by residents in small and large community bins. The remaining waste comes from street sweeping and drain cleaning. The existing community bins are permanent, stationary enclosures created using low height masonry walls. The masonry walls break easily in a few years, and currently, many of the community bins are in broken condition. The size of these bins is specific to the road and site conditions.

Waste samples were collected from four different locations in the city and characterized physically and chemically. All separable physical components of the bulk waste were segregated manually on-site. Mixed residue was defined for this study as the inseparable mixture of inertmaterials like sand, silt and ash along with organic matter like food and garden waste. Proximate analyses of all collected samples (mixed residue) were done in the lab and the results are shown in Table 5. This is the biggest bin in the entire municipal area and is located on the connecting road to the national highway, NH-4. This area comes in the higher income group residential area, where most of the commercial places and shopping complexes are located. Laborers use handcarts to collect wastes fromsix municipalwards and bring them to this community bin. Truck and tractors collect and transport solid waste from this bin to the disposal site. This bin is in an area which has a railway track passing through it and residents of this area come from low income groups. Waste is collected from this bin more frequently than from the others to prevent unhygienic conditions from developing.

As is apparent from Tables 4-6, solid waste composition, physical and chemical, was not significantly affected by bin location. Mixed residue was found to be about 80% of the bulkwaste that comes to the collection bins. Recyclable materials like paper, plastic, glass, polythene bags, textiles, and metals were a small fraction of the bulkwaste, unlike the fractions observed in middle and high income countries. 'Segregation at source' is conventionally practiced in low- and middle-income households, which accounts for the very small amounts of recyclables thrown in community bins. Also, the small amounts of recyclables found in community bins are generally collected by ragpickers and the remaining mixed residue is dumped on open land or in way-side drains. Proximate analyses of the samples collected showed that moisture content is a substantial fraction of the total weight of the mixedresiduesample andmostsamples have moisture content that varies from 32 to 52%. Total solids include volatile solids (organic matter) and fixed solids (inorganic or inert materials) and varied from 47 to 69% of the sample weight.

Volatile solids in most samples were found to vary from 10 to 30% of the total solids while the organic carbon content varied from 3 to 15%. The waste samples examined in this study had relatively low COD and calorific values, making energy recovery a difficult proposition.

Physcical and chemical analyses were shown in Table 4-6. Moisture content of solid waste is usually expressed as the weight of moisture per unit weight of wet material. The data indicates that moisture content of solid waste varies from 24.33% to 42.20%. On average the LCV of waste is about 2000k cal/ kg from residential area, about 4000 kcal/kg from commercial area and about 400 kcal/kg from weekly market whereas about 2800kcal/ kg from vegetable and fruit markets. On average the HCV of waste is about 2200-2400 kcal/kg from residential area, about 4000 kcal/ kg from commercial area and about 400 kcal/ kg from weekly market where as about 3000 kcal/kg from vegetables and fruit markets. There is not significant difference in LCV and HCV of waste. The calorific value varies between 378 to 4680 kcal/kg as lower calorific value. The LCV indicates the calorific value of the solid waste in the existing state. The calorific value varies between 402 to 4705 kcal per kg as higher calorific value. While the carbon content of the refuse range between 22.05 to 34.28%. The hydrogen, oxygen and sulphur content of the refuse are in the range of 4 to 7.28%; 39.06 to 53.15% and 0.15 to 0.55% respectively. C/N ratio is between 16.53 to 33.77. High volatile matter is 32.3-52.20%. Recyclable components such as plastic, paper, metal and textiles are smaller fractions in developing countries than in advanced cities/ countries, which is attributable to greater usage of paper and plastic along with electronic media in advanced countries. In India, recyclables are mostly segregated at source and ragpickers take away any remaining portions from the waste that is brought to community bins or open dumps. For disposal ofwaste, incineration is uneconomical due to the low calorific value and high moisture content of MSW. The solidwaste generated in Kharagpur consists of considerable moisture, a favorable condition for compostingwaste. However, the low organic content makes it unsuitable for composting in 'as-is' conditions. Therefore, segregation at source of the biodegradable (mainly kitchen and garden waste) and nonbiodegradable components of household waste is recommended so that the high organic content of wet waste can be used for composting.

Table 1. Average quantity of waste disposal per day to Bhanpura dumping site

S. No.	Date	Quantity of SWM disposal (MT/day)
1.	18-12-2009	368. 59
2.	19-12-2009	353. 65
3.	20-12-2009	347. 65
4.	21-12-2009	329. 05
5.	22-12-2009	309. 35
6.	23-12-2009	337. 01
7.	24-12-2009	Holiday
8.	25-12-2009	345.635
	Average	**341.56**

Table 2. Solid waste generation from year 2008-2023.

Ward number	NAME OF THE WARD	Population 2008	Waste Generation (MT/day) 2008	Population 2013	Waste Generation (MT/day) 2013	Population 2018	Waste Generation (MT/day) 2018	Population 2023	Waste Generation (MT/day) 2023
1	Mahatma Gandhi	41098	12.38	50321	15.93	59669	19.86	66467	23.25
2	C.T.O.	22256	6.71	27470	8.70	32808	10.92	36691	12.83
3	Hemu Kalani	20700	6.24	24351	7.71	27924	9.29	30522	10.68
4	Sadhu waswani	30227	9.11	36056	11.42	41850	13.93	46.64	16.11
5	Koh-E-Fiza	21552	6.49	25507	8.08	29394	9.78	32222	10.27
6	Noor mahal	20220	6.09	23768	7.53	27235	9.06	29757	10.41
7	Malipura	17005	5.12	20036	6.34	23006	7.66	25165	8.80
8	Bagh munsi husain	21020	6.33	25703	8.14	30469	10.14	33936	11.87
9	Idgah hills	29306	8.83	34393	10.89	39345	13.09	42947	15.02
10	Babu Jagjivan	19408	5.85	20856	6.60	21894	7.29	22649	7.92
11	Gufa mandir	45850	13.81	53706	17.01	61330	20.41	66874	23.39
12	Geetanjali	25949	7.82	30459	9.64	34862	11.60	38065	13.31
13	Shahjanabad	26014	7.84	29284	9.27	32229	10.73	34372	12.02
14	Congress Nagar	23730	7.15	27904	8.84	31986	10.64	34953	12.23
15	Motilal Nehru	26319	7.93	30757	9.74	35058	11.67	38185	13.36
16	J.P.Nagar	17179	5.13	20655	6.54	24141	8.03	26676	9.33
17	Ibrahim Ganj	28812	8.68	33812	10.71	38688	12.88	42235	14.77
18	Ram Mandir	15433	4.65	18187	5.76	20890	6.95	22857	7.99
19	Mangala wara	15182	4.57	17909	5.67	20588	6.85	22535	7.88
20	Lal Bhadur Shastri	16195	4.88	18586	5.89	20836	6.93	22473	7.86
21	Mahavir	15808	4.76	18629	5.90	21394	7.12	23406	8.19
22	Jain Mandir	12881	3.83	15209	4.82	17497	5.82	19160	6.70
23	Moti Masjid	22540	6.79	25701	8.14	28637	9.53	30773	10.76
24	Islam pura	15222	4.59	16772	5.31	18069	6.01	19011	6.65
25	Bhojpura	20795	6.27	24466	7.75	28055	9.34	30665	10.73
26	Rani Kamlapati	18158	5.47	21469	6.80	24721	8.23	27086	9.47
27	Vivekanand	25067	7.55	30080	9.52	35111	11.68	38769	13.56
28	Ambedkar	29369	8.85	34453	10.91	39403	13.11	43003	15.04
29	Tulsi Nagar	31686	9.55	37051	11.73	42255	14.06	46040	16.10
30	Pansheel Nagar	19117	5.76	22474	7.12	25758	8.57	28145	9.84

31	Maulana Azad	44611	13.44	53856	17.05	63165	21.02	69935	24.46
32	Shivaji Nagar	21989	6.62	26376	8.35	30761	10.24	33949	11.87
33	T.T.Nagar	14094	4.24	16695	5.29	19258	6.41	21122	7.79
34	Jawahar Lal Nehru	15459	4.66	18223	5.77	20938	6.97	22912	8.01
35	Pt.Madan mohan	31929	9.62	37777	11.96	43550	14.49	47748	16.70
36	R.N.Tagore	23204	6.99	27928	8.84	32670	10.87	36117	12.63
37	Jahangirabad	21575	6.50	25352	8.03	29039	9.66	31721	11.10
38	Berkhedi	20901	6.30	24167	7.65	27282	9.08	29547	10.33
39	Chandbad	22478	6.77	26421	8.37	30273	10.08	33075	11.57
40	Kapda Mill	32193	9.70	37949	12.02	43561	14.50	47643	16.66
41	Bagh umrao dulah	36760	11.08	43087	13.64	49245	16.39	53723	18.79
42	Aish Bagh	44062	13.28	51653	16.36	59036	19.65	64405	22.53
43	Maharani lax,bai	18163	5.47	20730	6.56	23117	7.69	24853	8.69
44	Zinci	16400	4.94	16800	5.32	17200	5.59	17600	5.88
45	Maida Mill	22550	6.79	26501	8.39	30357	10.10	33161	11.60s
46	Neta Subchandra	31115	9.37	36671	11.61	42120	14.02	46082	16.12
47	Maharana Pratap	19295	5.81	22714	7.19	26058	8.67	28491	9.97
48	Ravishankar Ngr.	24974	7.52	29357	9.30	33632	11.19	36740	12.85
49	Dr. Rajendra Prasad	36123	10.88	43366	13.73	50600	16.84	55861	19.54
50	Indra Gandhi	30174	9.09	35404	11.21	40498	13.48	44202	15.46
51	Shahpura	29609	8.92	34754	11.00	39774	13.24	43425	15.19
52	Asha Niketan	52709	15.88	61787	19.56	70626	23.50	77053	26.95
53	Barkatullah	44125	13.29	54597	17.29	65114	21.67	72762	25.45
54	Berkheda Pathani	40690	12.26	49991	15.83	59524	19.81	66456	23.25
55	Saket,Shakti Nagar	17816	5.37	20930	6.63	23994	7.99	26221	9.17
56	Kasturba Nagar	23607	7.11	27791	8.80	31875	10.61	34846	12.19
57	Anna Nagar	14816	4.46	17469	5.33	20072	6.68	21964	7.68
58	Berkheda (BHEL)	16533	4.98	19445	6.16	22285	7.42	24351	8.52
59	Govindpura	17629	5.31	20744	6.57	23772	7.91	25975	9.09
60	Piplani	29506	8.89	37561	11.89	45969	15.30	52084	18.22
61	Gautam Budh	15788	4.76	18612	5.89	21354	7.11	23348	8.17
62	Sonagiri	46412	13.98	56098	17.76	65821	21.91	72893	25.50
63	Indrapuri	56587	17.05	66280	20.99	75725	25.20	82593	28.89
64	Guru Nanak	47181	14.21	55262	17.50	63120	21.01	68835	24.08
65	Rajeev Nagar	44867	13.52	56319	17.83	68225	22.71	76883	26.89
66	Nabi Bagh	84495	25.46	100856	31.94	117221	39.01	129124	45.16

Source: BMC, 2009

Table 2. Calculation of containers

Assuming Density 300Kg Solid Waste Generation 0.303kg/Cap/day						Assuming Density 300Kg Solid Waste Generation 0.5kg/Cap/day					Assuming Density 300Kg Solid Waste Generation 0.7 kg/Cap/day				
Ward No.	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container
1.	44.7	2	9	35.77	32	73.88	2	9	64.88	58	103.43	2	9	94.43	85
2.	24.28	2	9	15.28	13	40.08	2	9	31.08	28	56.11	2	9	47.11	42
3.	22.28	3	13.5	8.78	7	36.76	3	13.5	23.26	21	51.47	3	13.5	37.97	34
4.	32.66	2	9	23.66	21	53.90	2	9	44.9	40	75.46	2	9	66.46	60
5.	23.24	NA	NA	NA	NA	38.35	NA	NA	NA	NA	53.69	NA	NA	44.69	NA
6.	21.76	2	9	12.76	11	35.90	2	9	26.9	24	50.27	2	9	41.27	37
7.	18.31	2	9	9.31	8	30.32	2	9	21.22	19	42.30	2	9	33.3	30
8.	22.87	3	13.5	9.37	8	37.74	3	13.5	24.24	22	52.84	3	13.5	39.34	35
9.	31.53	1	4.5	27.03	24	52.03	1	4.5	47.53	43	72.84	1	4.5	68	62
10.	20.39	2	9	11.39	10	33.65	2	9	24.65	22	47.17	2	9	38.17	34
11.	49.30	1	4.5	44.8	40	81.36	1	4.5	76.86	69	113.91	1	4.5	109.41	99
12.	27.91	NA	NA	NA	NA	46.06	NA	NA	NA	NA	64.48	NA	NA	NA	NA
13.	27.66	NA	NA	NA	NA	45.66	NA	NA	NA	NA	63.92	NA	NA	NA	NA
14.	25.54	NA	NA	NA	NA	42.14	NA	NA	NA	NA	59.00	NA	NA	NA	NA
15.	28.28	1	4.5	23.78	21	46.66	1	4.5	42.16	38	65.33	1	4.5	60.83	55
16.	18.60	NA	NA	NA	NA	30.70		NA	NA	NA	42.98		NA	NA	NA
17.	30.99	7	31.5	-0.91	.82	51.44	7	NA	NA	NA	71.60	7	NA	NA	NA
18.	16.61	5	NA	NA	NA	27.42	5	NA	NA	NA	38.39	5	NA	NA	NA
19.	16.35	NA	NA	NA	NA	26.98	NA	NA	NA	NA	37.78	NA	NA	NA	NA
20.	17.31	1	4.5	12.81	11	28.57	1	4.5	24.07	21	40	1	4.5	35.5	32
21.	17.02	2	9	8.02	7	28.09	2	9	19.09	17	39.33	2	9	30.33	27
22.	13.87	2	9	4.87	4	22.90	2	9	13.9	12	32.06	2	9	23,06	20
23.	24.05	2	9	15.05	13	39.69	2	9	30.69	27	55.37	2	9	46.57	42
24.	16.10	3	13.5	2.6	2	26.56	3	13.5	13.06	11	37.19	3	13.5	23.69	21
25.	22.38	1	4.5	17.88	16	36.94	1	4.5	32.44	29	51.71	1	4.5	47.21	42
26.	19.57	1	4.5	15.07	13	32.30	1	4.5	27.8	25	45.22	1	4.5	40.72	37
27.	27.12	1	4.5	22.62	20	44.75	1	4.5	40.25	36	62.66	1	4.5	58.16	52
28.	51.59	2	9	22.59	20	52.13	2	9	43.13	39	72.98	2	9	63.98	58
29.	34.05	NA	NA	NA	NA	56.19	NA	NA	NA	NA	78.66	NA	NA	NA	NA
30.	20.57	NA	NA	NA	NA	33.94	NA	NA	NA	NA	47.52	NA	NA	NA	NA
31.	48.36	NA	NA	NA	NA	79.11	NA	NA	NA	NA	111.74	NA	NA	NA	NA

32.	23.80	NA	NA	NA	NA	39.27	NA	NA	NA	NA	54.98	NA	NA	NA	NA
33.	15.20	NA	NA	NA	NA	25.08	NA	NA	NA	NA	35.11	NA	NA	NA	NA
34.	16.64	2	9	7.64	6	27.47	9	18.47	18.47	16	38.46	2	9	29.46	26
35.	34.41	2	9	25.41	23	56.79	2	9	47.79	43	79.51	2	9	70.51	64
36.	25.13	4	18	7.13	6	41.48	4	18	23.48	21	58.07	4	18	40.07	36
37.	23.21	1	4.5	18.71	17	38.31	1	4.5	33.81	30	53.63	1	4.549	44	34
38.	22.39	2	9	13.39	12	36.95	2	9	27.95	25	51.73	2	9	42.73	38
39.	24.19	2	9	15.19	13	39.92	2	9	30.92	28	55.88	2	9	46.88	42
40.	34.69	2	9	25.69	23	57.25	2	9	48.25	43	80.15	2	9	71.15	64
41.	39.53	NA	NA	NA	NA	65.23	NA	NA	NA	NA	91.32	NA	NA	NA	NA
42.	47.39	2	9	38.39	34	78.20	2	9	69.2	62	109.48	2	9	100.48	91
43.	19.39	2	9	10.39	9	32.0	2	9	23	20	44.08	2	9	35.08	31
44.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45.	24.26	2	9	15.26	13	40.04	2	9	31.04	28	56.06	2	9	47.06	42
46.	33.51	3	13.5	20.01	18	55.29	3	13.5	41.79	37	77.41	3	13.5	63.91	58
47.	20.77	NA	NA	NA	NA	34.28	NA	NA	NA	NA	47.99	NA	NA	NA	NA
48.	26.88	1	4.5	22.38	20	44.36	1	4.5	39.86	36	62.10	1	4.5	57.6	52
49.	39.11	1	4.5	34.61	31	64.54	1	4.5	60.04	54	90.36	1	4.5	85.86	78
50.	32.45	3	13.5	18.95	17	53.56	3	13.5	40.06	36	74.94	3	13.5	61.48	55
51.	31.85	2	9	22.85	20	52.56	2	9	43.56	39	73.58	2	9	64.58	58
52.	56.68	NA	NA	NA	NA	19.53	NA	NA	NA	NA	130.95	NA	NA	NA	NA
53.	48.33	1	4.5	43.83	39	79.76	1	4.5	75.26	68	111.66	1	4.5	107.16	97
54.	44.31	NA	NA	NA	NA	73.13	NA	NA	NA	NA	102.38	NA	NA	NA	NA
55.	19.15	1	4.5	14.65	13	31.61	1	4.5	27.11	24	44.25	1	4.5	39.75	36
56.	25.42	NA	NA	NA	NA	41.95	NA	NA	NA	NA	58.73	NA	NA	NA	NA
57.	15.95	NA	NA	NA	NA	26.33	NA	NA	NA	NA	36.86	NA	NA	NA	NA
58.	17.80	NA	NA	NA	NA	29.37	NA	NA	NA	NA	41.12	NA	NA	NA	NA
59.	18.99	NA	NA	NA	NA	31.33	NA	NA	NA	NA	43.87	NA	NA	NA	NA
60.	32.49	NA	NA	NA	NA	53.61	NA	NA	NA	NA	75.06	NA	NA	NA	NA
61.	17.02	1	4.512.52	12.52	11	28.09	1	4.5	23.59	21	39.32	1	4.5	34.82	31
62.	50.36	NA	NA	NA	NA	83.10	NA	NA	NA	NA	116.35	NA	NA	NA	NA
63.	60.82	NA	NA	NA	NA	100.37	NA	NA	NA	NA	140.52	NA	NA	NA	NA
64.	50.72	NA	NA	NA	NA	83.70	NA	NA	NA	NA	117.19	NA	NA	NA	NA
65.	49.17	NA	NA	NA	NA	81.14	NA	NA	NA	NA	113.60	NA	NA	NA	NA
66.	91.26	NA	NA	NA	NA	150.61	NA	NA	NA	NA	210.85	NA	NA	NA	NA
	Total	**82**			**626**		**82**			**1189**		**82**			**1847**

Source: BMC, 2009; NA- Not Available

Table 3. Calculation of containers

Assuming Density 400Kg Solid Waste Generation 0.303kg/Cap/day						Assuming Density 400Kg Solid Waste Generation 0.5kg/Cap/day					Assuming Density 400Kg Solid Waste Generation 0.7 kg/Cap/day				
Ward No.	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container	Total Volume	No. of 4.5 m^3 container	Total volume of 4.5 m^3	Balance Volume	No. of 1.1 m^3 container
1.	33.57	2	9	24.57	22	55.41	2	9	46.41	42	77.57	2	9	68.57	62
2.	18.21	2	9	9.21	8	30.06	2	9	21.06	19	42.08	2	9	33.08	30
3.	16.71	3	13.5	3.21	2	27.57	3	13.5	14.07	12	38.60	3	13.5	25.1	22
4.	24.49	2	9	15.44	14	40.42	2	9	31.42	28	56.59	2	9	47.59	43
5.	17.43	NA	NA	NA	NA	28.76	NA	NA	NA	NA	40.26	NA	NA	NA	NA
6.	16.32	2	9	7.32	6	26.92	2	9	17.92	16	37.70	2	9	28.7	26
7.	13.73	2	9	4.73	4	22.69	2	9	13.66	12	31.72	2	9	22.72	20
8.	17.15	3	13.5	8.15	7	28.30	3	13.5	14.8	13	39.63	3	13.5	26.13	23
9.	23.64	1	4.5	19.14	17	39.02	1	4.5	34.52	31	54.63	1	4.5	50.13	45
10.	15.29	2	9	6.29	5	25.23	2	9	16.23	14	35.37	2	9	26.37	23
11.	36.97	1	4.5	32.47	29	61.02	1	4.5	56.52	51	85.43	1	4.5	80.	73
12.	20.93	NA	NA	NA	NA	34.54	NA	NA	NA	NA	48.36	NA	NA	NA	NA
13.	20.74	NA	NA	NA	NA	34.24	NA	NA	NA	NA	47.94	NA	NA	NA	NA
14.	19.15	NA	NA	NA	NA	31.60	NA	NA	NA	NA	44.25	NA	NA	NA	NA
15.	21.21	1	4.5	16.71	15	34.99	1	4.5	30.49	27	48.99	1	4.5	44.49	40
16.	13.95	NA	NA	NA	NA	23.02	NA	NA	NA	NA	32.23	NA	NA	NA	NA
17.	23.34	7	31.5	8.26	7	38.58	7	31.5	7.08	6	53.7	7	31.5	22.2	20
18.	12.45	5	22.5	-10.05	-9	20.56	5	22.5	-1.94	-1	28.79	5	22.5	6.29	5
19.	12.26	NA	NA	NA	NA	20.23	NA	NA	NA	NA	28.33	NA	NA	NA	NA
20.	12.98	1	4.5	8.14	7	21.42	1	4.5	16.92	15	30.0	1	4.5	25.5	23
21.	12.76	2	9	3.76	3	21.06	2	9	12.06	10	29.49	2	9	20.49	18
22.	10.38	2	9	1.38	1	17.17	2	9	8.17	7	24.04	2	9	15.04	13
23.	18.03	2	9	9.03	8	29.76	2	9	20.76	18	41.67	2	9	32.67	29
24.	12.07	3	13.5	-1.43	-1.3	19.92	3	13.5	6.42	5	27.89	3	13.5	14.39	13
25.	16.78	1	4.5	12.28	11	27.70	1	4.5	23.2	21	38.78	1	4.5	34.28	31
26.	14.67	1	4.5	10.17	9	24.22	1	4.5	19.72	17	33.51	1	4.5	29.01	26
27.	20.34	1	4.5	15.84	14	33.56	1	4.5	29.06	26	46.99	1	4.5	42.43	38
28.	23.69	2	9	14.69	13	39.09	2	9	30.09	27	54.73	2	9	45.73	41
29.	25.53	NA	NA	NA	NA	42.14	NA	NA	NA	NA	58.99	NA	NA	NA	NA
30.	15.42	NA	NA	NA	NA	25.45	NA	NA	NA	NA	35.64	NA	NA	NA	NA
31.	36.27	NA	NA	NA	NA	59.85	NA	NA	NA	NA	83.80	NA	NA	NA	NA

32.	17.85	NA	NA	NA	NA	29.45	NA	NA	NA	NA	41.23	NA	NA	NA	NA
33.	11.4	NA	NA	NA	NA	18.81	NA	NA	NA	NA	26.33	NA	NA	NA	NA
34.	12.48	2	9	3.48	3	20.60	2	9	11.60	10	28.84	2	9	19.84	18
35.	25.80	2	9	16.8	15	42.59	2	9	33.59	30	59.63	2	9	50.63	46
36.	18.84	4	18	0.84	0.76	31.11	4	18	13.11	11	43.55	4	18	25.55	23
37.	17.40	1	4.5	12.9	11	28.73	1	4.5	24.23	22	40.22	1	4.5	35.72	32
38.	16.39	2	9	7.79	7	27.71	2	9	18.71	17	38.79	2	9	29.79	27
39.	15.14	2	9	9.14	8	29.94	2	9	20.94	19	41.91	2	9	32.91	29
40.	26.01	2	9	17.01	15	42.93	2	9	33.93	30	60.11	2	9	51.11	46
41.	29.64	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
42.	35.54	2	9	26.54	24	58.65	2	9	49.65	45	82.11	2	9	73.11	66
43.	14.54	2	9	5.54	5	24.00	2	9	15	13	33.06	2	9	24.06	21
44.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
45.	18.19	2	9	9.19	8	30.03	2	9	21.03	19	42.04	2	9	33.04	30
46.	25.13	3	13.5	11.63	10	41.46	3	13.5	27.96	25	58.05	3	13.5	44.55	40
47.	15.57	NA	NA	NA	NA	25.71	NA	NA	NA	NA	35.99	NA	NA	NA	NA
48.	20.16	1	4.5	15.66	14	33.27	1	4.5	28.77	26	46.57	1	4.5	42.07	38
49.	29.33	1	4.5	24.83	22	48.40	1	4.5	43.9	39	67.77	1	4.5	63.27	57
50.	24.33	3	13.5	10.83	9	40.17	3	13.5	26.67	24	56.23	3	13.5	42.73	38
51.	23.88	2	9	14.88	13	39.42	2	9	30.42	27	55.18	2	9	46.	41
52.	42.51	NA	NA	NA	NA	70.14	NA	NA	NA	NA	98.21	NA	NA	NA	NA
53.	36.24	1	4.5	31.74	28	59.82	1	4.5	55.32	50	83.74	1	4.5	79.24	72
54.	33.23	NA	NA	NA	NA	54.84	NA	NA	NA	NA	76.78	NA	NA	NA	NA
55.	14.36	1	4.5	9.86	8	23.70	1	4.5	19.2	17	33.18	1	4.5	28.68	26
56.	19.06	NA	NA	NA	NA	31.46	NA	NA	NA	NA	44.04	NA	NA	NA	NA
57.	11.96	NA	NA	NA	NA	19.74	NA	NA	NA	NA	27.64	NA	NA	NA	NA
58.	13.35	NA	NA	NA	NA	22.02	NA	NA	NA	NA	30.84	NA	NA	NA	NA
59.	14.24	NA	NA	NA	NA	23.49	NA	NA	NA	NA	32.90	NA	NA	NA	NA
60.	24.36	NA	NA	NA	NA	40.20	NA	NA	NA	NA	56.29	NA	NA	NA	NA
61.	12.76	1	4.5	8.26	7	21.06	1	4.5	16.56	15	29.59	1	4.5	24.99	22
62.	37.77	NA	NA	NA	NA	62.32	NA	NA	NA	NA	87.26	NA	NA	NA	NA
63.	45.61	NA	NA	NA	NA	75.27	NA	NA	NA	NA	105.39	NA	NA	NA	NA
64.	38.04	NA	NA	NA	NA	62.77	NA	NA	NA	NA	87.89	NA	NA	NA	NA
65.	36.87	NA	NA	NA	NA	60.85	NA	NA	NA	NA	85.2	NA	NA	NA	NA
66.	68.44	NA	NA	NA	NA	112.95	NA	NA	NA	NA	158.13	NA	NA	NA	NA
	Total	**82**			**409**		**82**			**826**		**82**			**1336**

Source: BMC, 2009; NA- Not Available

Table 4. Density and Calorific value of Municipal Solid Waste in Bhopal.

Sample Code No.	Sample Category	Density (kg/cum)	Higher Calorific Value(kcal/kg	Lower Calorific Value (kcal/kg)
1.1	HIG	323	2567	2346
1.2	HIG	319	2411	2204
1.3	HIG	306	2195	1948
2.1	MIG	284	2186	1829
2.2	MIG	323	2087	1856
2.3	MIG	255	3215	3079
2.4	MIG	287	2307	2115
2.5	MIG	302	2460	2289
2.6	MIG	312	2340	2140
3.1	LIG	217	2578	2389
3.2	LIG	300	2260	2010
3.3	LIG	227	1454	1326
3.4	LIG	251	2574	2339
3.5	LIG	288	2390	2179
3.6	LIG	257	2294	2077
3.7	LIG	280	2294	2077
4.1	EWS	214	2616	2427
4.2	EWS	314	1270	1136
4.3	EWS	305	2249	2021
4.4	EWS	290	2181	1949
4.5	EWS	261	2613	2455
5.1	Commercial	334	4705	4680
5.2	Commercial	329	3656	3612
6.1	Vegetable &Fruit market	281	3001	2835
6.2	Vegetable &Fruit market	284	2912	2717
7.1	Weekly Market	45	402	378
7.2	Weekly Market	43	426	403
8.1	Hotels	414	2249	2028
8.2	Hotels	386	2562	2346
9.1	Restaurants	366	2584	2394
9.2	Restaurants	348	2721	2576
10.1	Garden	224	2261	2034
11.1	Dumping Site (Fresh Garbage)	380	2273	2113
11.2	Dumping Site (Old Garbage)	376	1283	1261
11.3	Dumping Site (Old Garbage)	411	490	488
	Average	**290**	**2376**	**2193**

Table 5. Proximate Analysis of Municipal Solid Waste in Bhopal

Sample Code	Moisture %	Volatile matter %	Ash %	Fixed carbon %
1.1	25.63	48.3	15.03	11.03
1.2	34.76	44.96	11.3	9.03
1.3	24.33	46.23	17.93	11.5
2.1	24.93	52.2	12.5	10.36
2.2	30.33	44.86	12.56	12.23
2.3	27.03	45.86	16.13	10.96
2.4	31.13	44	16.76	8.1
2.5	25.03	47.7	16.66	10.6
2.6	29.86	47.36	12.93	9.83
3.1	28.33	47.83	14.3	9.53
3.2	42.2	38.83	12.6	6.36
3.3	34.1	40.73	14.46	10.7
3.4	28.36	44.53	17.93	9.16
3.5	34.73	40.9	17.56	6.8
3.6	26.63	40.73	14.56	8.06
3.7	34.93	38.7	18.13	8.23
4.1	30.1	47.33	11.9	10.66
4.2	26.53	51.16	16.9	5.4
4.3	28.4	49.06	14.66	7.86
4.4	34.06	43.33	14.86	7.73
4.5	33.16	41.33	17.96	7.53
5.1	31.63	45.6	15.26	7.5
5.2	39.86	33	17.83	9.3
6.1	24.33	49.23	16.06	10.36
6.2	30.3	44.33	16.36	9
7.1	24.5	50.6	17.33	7.56
7.2	27.46	48.43	16.2	7.9
8.1	32.1	51.4	9.9	6.6
8.2	38.1	37.3	21.21	3.4
9.1	41.8	32.3	16.93	9
9.2	28.3	46.6	15.47	9.7
10.1	32.4	39.9	18.44	9.3
11.1	33.1	37.3	18.18	11.5
11.2	21.6	46.3	22.93	9.2
11.3	16.2	58.1	14.54	11.2
Average	**31.10**	**44.52**	**15.58**	**8.79**

Note: All the values are in percentage on dry weight basis.

Table 5. Ultimate Analysis of Municipal Solid Waste in Bhopal.

Sample code	Carbon %	Hydrogen %	Oxygen %	Nitrogen %	Sulphur %	Phosp-horus %	Potash %	Ash %	C/N Ratio
1.1	27.05	6.04	53.13	0.85	0.52	0.6	0.71	16.1	25.94
1.2	28.67	6.67	50.05	0.82	0.21	0.62	0.46	12.5	34.96
1.3	26.35	6.01	46.06	0.84	0.16	0.84	0.84	18.9	31.36
2.1	21.76	6.45	55.24	0.9	0.55	0.75	0.85	13.5	24.17
2.2	30.05	7.04	45.93	1.21	0.55	0.77	0.82	13.63	24.83
2.3	35.76	4.07	39.06	1.25	0.54	0.92	0.86	17.54	28.6
2.4	23.58	6.25	49.75	0.74	0.18	0.95	0.87	17.68	31.86
2.5	23.35	5.87	49.84	0.86	0.13	0.84	0.91	18.2	27.15
2.6	34.28	6.23	42.94	0.84	0.12	0.72	0.62	14.25	40.8
3.1	24.99	6.21	49.51	0.74	0.87	1.13	0.92	15.63	33.77
3.2	25.55	8.24	49.95	1.08	0.63	0.84	0.51	13.2	23.65
3.3	28.98	6.17	45.51	1.47	0.18	0.68	0.81	16.2	19.71
3.4	26.09	6.28	43.91	1.55	0.67	0.72	1.24	19.54	16.83
3.5	23.93	4.58	49.39	1.24	0.25	0.74	0.62	19.25	19.29
3.6	25.32	5.52	49.67	1.27	0.45	0.97	0.84	15.96	19.93
3.7	25.81	5.55	44.9	1.56	0.82	0.91	0.82	19.63	16.54
4.1	29.65	6.68	47.11	1.25	0.15	1.25	0.71	13.2	23.72
4.2	26.07	6.48	45.25	1.28	0.34	0.86	0.84	18.88	20.36
4.3	29.05	4.2	47.78	1.16	0.41	0.74	0.92	15.74	25.04
4.4	27.9	4.54	48.07	0.84	0.46	1.27	0.68	16.24	33.21
4.5	26.88	5.67	45.29	0.97	0.46	0.81	0.72	19.2	27.71
5.1	30.32	4.2	45.88	1.05	0.17	0.84	0.91	16.63	28.87
5.2	25.11	3.65	48.65	1.22	0.25	0.91	0.81	19.4	20.58
6.1	32.22	6.23	40.54	1.24	0.24	0.91	1.1	17.52	25.98
6.2	27.33	5.54	47.06	0.82	0.41	0.81	0.72	17.31	33.32
7.1	27.55	5.81	43.89	0.93	0.51	2	0.91	19.2	29.62
7.2	32.55	5.82	40.3	1.26	0.18	0.97	0.81	18.11	25.83
10.1	28.82	7.24	50.28	1.24	0.67	0.71	0.84	10.2	23.24
10.2	25.57	5.54	42.94	0.86	0.46	0.66	0.81	23.16	29.73
11.1	23.49	7.27	48.59	0.82	0.13	0.77	0.61	18.32	28.64
11.2	26.35	5.24	48.72	1.14	0.42	0.82	0.81	16.5	23.11
12	22.44	5.24	48.99	1.07	0.18	0.92	0.71	20.45	20.97
15.1	25.6	7.28	45.33	0.94	0.22	0.87	0.62	19.14	27.23
15.2	22.3	4.28	45.95	0.85	0.24	0.74	0.74	24.9	26.23
15.3	29.9	4.24	46.32	1.08	0.41	0.48	0.88	16.69	27.68
Average	**27.02**	**5.78**	**46.91**	**1.06**	**0.38**	**0.84**	**0.80**	**17.21**	**26.30**

Note: All the values are in percentage on dry weight basis.

Daily collection of solid waste is essential due to the high moisture content of MSW, considerable amounts of biodegradable materials in the waste and extremely hot, and humid climate. The waste 'as-is' has low organic content and cannot be easily composted. However, if the biodegradable component can be separated from the non-biodegradable materials at source, compost can be generated, and used as a soil conditioner for farming and horticultural purposes. Composting options include home composting, full-scale aerobic or anaerobic composting and vermicomposting[4]. Home composting requires voluntary action from residents where they segregate their 'wet' and 'dry' waste at source[5]. Wet waste includes mainly food and kitchen waste, which is highly biodegradable while the remaining waste, which is mostly dry includes sand, soil, paper, plastic, metals, *etc*. Separation of the biodegradable components of waste will allow compost to be generated for domestic use and prevent this waste fraction from going to a landfill. This is in keeping with the Municipal SolidWaste (Management and Handling) Rules, 2000 [6], and is a proactive method for diverting organics from the waste stream, leading to cost savings associated with reduced storage, transport and ultimate disposal requirements. Where home composting is not done, large-scale composting plants can be set-up that would allow huge amounts of organic wastes to be converted to useful compost[4]. This compost can then be sold to farmers for its beneficial uses as a soil conditioner and supplemental fertilizer.

Conclusion and Recommendations

The paper deals existing system of MSWM in Bhopal and needs lot of improvement and modernization were discussed. Average value of different proximate parameter were moisture content (31.1%), volatile matter (44.5%), Ash (15.58%), fixed carbon (8.79%), respectively. Some of ultimate analysis parameter were calculated: Average value of C (27.02%), H (5.78%), O (46.9%), N (1.06), S (0.34%), P(0.84%), K (0.8%) and C/N ratio (26.3%), respectively. This results were showed that proper utilization of solid waste from different wards in Bhopal to make effective energy recovery and save for future purposes. Bhopal Municipal Area more tons of solid waste per day, whereas less tons are collected by the existing solid waste collection system, demonstrating the need for augmentation of the present collection system. All vehicles are in deplorable condition and additional budget for maintenance is required. The current stationary container system needs to be replaced with hauled container system throughout the Bhopal municipality. Tricycle carts are required for collection of solid waste against the existing handcarts. Some community bins are not in good condition and disposal sites are not always in preferred locations.

Community bins need to be relocated and one or more new disposal sites need to be developed in an appropriate manner with treatment and engineered landfilling. The nature of the wastes indicated that amongst all recovery options, composting would be most appropriate as it would divert more than 80%

of the wastes from the traditional waste stream and provide compost which can be used to enrich soils in fields and gardens.

References

1. Municipal solid waste (Mangementa and Handling) Rules, New Delhi: MoEF (2000).
2. Katiyar, R.B., Suresh S., Sharma, A. K. Characterisation of Municipal Solid Waste Generated by the City of Bhopal, India. *International Journal of Chem. Tech. Research, 5(2),* 623-628 (2013).
3. APHA, standard methods for the examination of water and wastewater, 17th ed, NewYork: *American Publica Health Association:* (1988).
4. Goel, Municipal solid waste management in India: a Critical review. *NEERI JESE*, (2008).
5. Desai A. Present status and alternatives for SWM in Ahmedabad City. Bachelor's Thesis, Submitted to school of Building Science Technology, CEPT, Ahmedabad, (2000).
6. Ministry of Environment and forest (MoEF), Legistration; Available from http:// envfor.nic.in/legis/legis.html., (2008).