International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 467-473 1 May 2014

Urban Municipal Solid Waste Management in City of Lakes Bhopal - A Review

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Abstract

Waste management is a complex process that requires a lot of information from various sources such as factors on waste generation and waste quantity forecasts. When operations related to promotion of waste management systems are considered it is observed that generation of waste and planning is found to be influenced by different factor of which are impacted by socio demographics.The main aim of this paper is to review previously tested models related to municipal solid waste generation and identify possible factors which will help in identifying the crucial design options within the framework of statistical modelling.

Key Words

Municipal Solid Waste (MSW), Compost, Vermicompost, Thermophillic Composting,,Anaerobic Digestion, Aerobic Composting, Collection , Disposal, Source, Factors.

Introduction

People are crowding in Urban areas for employment opportunities, due to industrializa tion in and around urban areas. Growing population and growing needs are the well felt problems for researchers, planners, and executors. Observed effects of mega cities are decrease in farm and landfill areas. So it became urgent need to utilise maximum possible area for better crop yield and also better treatment of solid waste in minimum available area. In this particular research study researcher wishes to focus on the treatment of organic waste collected in the Capital of Madhya Pradesh, and emergent issues and the suitability of centralised and decentralised processes of treatment. It is essential to concentrate the study on the out-come of the different treatment methods like vermi-compost, compost, biogas generation, energy generation and try to find out the method by which all the waste can be treated effectively, in minimum possible time and also to overcome the problems in collection, transportation, segregation and treatment.

Study Area:

Bhopal Municipal Corporation (BMC) has about 285.88 sq. km. of area with about 1914339 population, according to census 2011.Average waste generation is about 350 gms. per capita per day, in Bhopal city.

Municipal Solid Waste:

As per projection, the waste generation quantities are estimated to increase from 427 metric tonnes per day in 2001 to 569 metric tonnes in 2011 and 886.5 metric tonnes per day in year 2021, in Bhopal.

Biodegradable Waste:

Biodegradable Waste consists of vegetable stems and left over vegetables, waste food from restaurants and houses, spoiled fruits and vegetables from market, garden waste etc. The sources of collection are scattered throughout the Madhya Pradesh is centrally located in the country (Figure 1.0 "insert a Map of Mdhya Pradesh and locate Bhopal city"), and is often called the heart of India due to its location in the geographic heart of India. It is a large state with its capital at Bhopal. Out of 6.7 metric tonnes to 5.69 metric tonnes of waste generated in Bhopal city, hardly 10 to 15 % is segregated at source, remaining 85% requires segregation.

The biodegradable waste is the waste which can bebiologically degraded, from complex organic to simpleform in the environment. In warm Indian conditions, organic waste decomposes quickly, within a day or so.

Qualitative and quantitative analysis of MSW

There are many categories of MSW such as food waste, rubbish, commercial waste, institutional waste, street sweeping waste, industrial waste, construction and demolition waste, and sanitation waste. MSW contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), compostable organic matter (fruit and vegetable peels, food waste) and soiled waste (blood stained cotton, sanitary napkins, disposable syringes) (Jha et al., 2003; Reddy and Galab, 1998; Khan, 1994).

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. With increasing urbanization and changing life styles, Indian cities now generate eight times more MSW than they did in 1947. Presently, about 90 million t of solid waste are generated annually as byproductsof industrial, mining, municipal, agricultural and other processes. The amount of MSW generated per capita is estimated to increase at a rate of 1–1.33% annually
(Pappu et al., 2007; Shekdar, 1999; Bhide and Shekdar, 1998). A host of researchers (Siddiqui et al., 2006; Sharholy et al., 2005; CPCB, 2004; Kansal, 2002; Singh and Singh, 1998;Kansal et al., 1998; Bhide and Shekdar, 1998; Dayal, 1994; Khan, 1994; Rao and Shantaram, 1993) have reported that the MSW generation rates in small towns are lower than

those of metrocities, and the per capita generation rate of MSW in India ranges from 0.2 to 0.5 kg/ day. It is also estimated that the total MSW generated by 217 million people living in urban areas was 23.86 million t/yr in 1991, and more than 39 million t in 2001. The quantity of MSW generated (CPCB, 2000) and the per capita generation rate of MSW (CPCB, 2004) are shown in Table 1 and Fig. 1, respectively.

3. MSW characteristics and composition

The composition and the quantity of MSW generated form the basis on which the management system needs to be planned, designed and operated. In India, MSW differs greatly with regard to the composition and hazardous nature, when compared to MSW in the western countries (Gupta et al., 1998; Shannigrahi et al., 1997; Jalan and Srivastava, 1995). The composition of MSW at generation sources and collection points was determined on a wet weight basis and it 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%). The C/N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg. The physical characteristics of MSW in metrocities are presented in Table 2. It has been noticed that the physical and chemical.

It can be seen from Table 1 and Fig. 1 that the per capita generation rate is high in some states (Gujrat, Delhi and Tamil Nadu) and cities (Madras, Kanpur, Lucknow and Ahmedabad). This may be due to the high living standards,the rapid economic growth and the high level of urbanization in these states and cities. However, the per capita generation rate is observed to be low in other states (Meghalaya, Assam, Manipur and Tripura) and cities (Nagpur, Pune and Indore).

Characteristics of MSW change with population density, as shown in Table 3 and Table 4 (Garg and Prasad, 2003;CPCB, 2000; Bhide and Shekdar, 1998). From Table 2, it is observed that the differences in the MSW characteristics indicate the effect of urbanization and development. In urban areas, the major fraction of MSW is compostable materials (40–60%) and inerts (30–50%). The relative percentage of organic waste in MSW is generally increasing with the decreasing socio-economic status; so rural households generate more organic waste than urban households. For example, in south India the extensive use of banana leaves and stems in various functions results in a large organic content in the MSW. Also, it has been noticed that the percentage of recyclables (paper, glass, plastic and metals) is very low, because of rag pickers who segregate and collect the materials at generation sources, collection points and disposal sites.

Treatment of Municipal Solid Waste (MSW):

Any solid waste management will emphasize first on maximum waste reduction and then on reuse, segregation at source, recycling, organic waste treatment and use of recycled products.

Segregation of Waste:

Dry and wet waste required to be segregated and collected at source, is the bottle neck of the Municipal Solid Waste Management.

Dealing with Biodegradable Waste:

Food to Animals:

During ancient days, left over food was given to animals and beggars and remaining was put in to pits for composting.

Anaerobic digestion:

Many microorganisms prevail naturally in absence of air and oxygen and also decompose organic matter. Anaerobic digestion on decomposition of organicmatter gives rise to methane which is 23 times more harmful than carbondioxide (Jonathan-Rouse) 1.Hence wherever anaerobic digestion treatment is employed for organic matter, it becomes vital to collect methane and use it. Actually such practice is used for animal and human waste but certain examples are there, that they are successful in generating methane and use it. Biogas is a source of energy with lowest carbon footprints of all. Methane can be burnt on simple stove. The main problem is the quality of waste. Sand, soil, plastic contamination in the waste reduces the effectiveness of the plant and chemical contamination could compromise the microorganisms as well as the resultant compost.

Aerobic Composting:

Compost is the product of controlled aerobic decomposition of organic waste with the use of microorganisms, insects and worms. Microorganisms thrive in a moist, warm environment with an abundance of air and organic matter'. The composting may be compromised because of extreme conditions of hot, cold, wet and dry. The decomposing activities of microorganisms generate heat even up to 65 degrees centigrade which is responsible for pathogen kill and denature seeds.

Compost is a stable, dark brown compound with soil like appearance. It can hold moisture, air and nutrients. Naturally made compost, smells like fresh forest floor and does not have rotten smell. Compost contains plant nutrients, minerals and also nitrogen, phosphorus and potassium (NPK),It also contains some microorganisms beneficial to plant growth. It can be used as a soil conditioner to reduce requirement of chemical fertilisers and also to reduce soil erosion.

Vermicomposting:

Through the simple act of eating, earthworms promote bacterial growth, enhance soil structure and hasten the decomposition of organic matter. However, due to different feeding habits, not all earthworms are suitable as a vermi culture. Earthworms are divided into two groups: humus formers and humus feeders. The first group dwells on the surface and feed on nearly 90% fresh organic materials and 10% soil. They are usually red in colour, have a flat tail and are also called epegic or detritivorous worms. It is these worms that are harnessed for Vermicomposting. The second group, the humus feeders, are deep burrowing worms those are useful in making soil porous and also mixing and distributing humus through the soil. Theearthworm species Eudriluseugeniae is widely used for this purpose. During the vermicomposting the substrate composition is very important. The composted product is very rich in nutrients called vermicast and also produces shiny water called vermiwash which is also rich in nutrients.

Thermophilic Composting and Vermicomposting:

During recent days due to less availability of land and huge quantity of biodegradable waste, it became very difficult to treat the same by city corporations. Considering this fact Thermophilic composting is preferred by city corporations.

In vermicomposting, the earthworms take over the role of turning and maintaining the material in an aerobic condition thereby reducing the need for mechanical operations. In addition to this the product vermicompost is homogenous. However, the major drawback of the vermicompost process is that the temperature is not high enough for pathogen kill. Where as in traditional thermophilic composting temperature exceeds 65 degrees centigrade, which is good enough for pathogen kill, as compare to less than 35 degrees centigrade maintained in case of vermicomposting.

Innovative Techniques:

With growing population and growing needs, waste generation has shown exponential growth in various cities like Bhopal. It is well felt problem for researchers, planners and executers. Naturally the issue attracted the attention of all that, how to overcome the problem? Because of this curiosity many experiments, many techniques were tried. Out of which some eye catching techniques like Pre-composting followed by Vermicompsting and Prevermicomposting followed by composting, are discussed in this research paper.

Precomposting followed by Vermicomposting:

Traditional thermophilic composting relate to the problem of long duration of the process, frequent turning of the material, raw material size reduction to increase the surface area. There is loss of nutrients to some extent because ofhigh temperature and prolonged process. Also resultant material is the heterogeneous product.

Prevermicomposting followed by composting:

In vermicomposting earthworms take over both the roles of turning and keeping the material in aerobic condition and thereby reducing the need of mechanical operation. The vermicomposting product is homogenous. The main drawback of the process is the process temperature is not high enough for pathogen kill (65 degrees centigrade or more). The vermicomposting process temperature is 35 degrees centigrade or less up to 28 degrees centigrade.

Comparison of Combined Processes:

During the study it is observed by the researcher that, the duration of the combined process viz. Thermophillic composting followed byVermi- composting is about four weeks. While in case of other combination, namely, Vermi-composting followed by Thermophllic composting, the time required only for vermicomposting is about 56 days minimum and then question of composting arise for ten days with higher temperature.

The combination of both these processes, in both the forms, shortened treatment and stabilization period and improved quality product. The end product is stable and consistent, and also with less bad impacts on environment and meet the requirement of pathogen kills.

Issues:

As per researcher's observations, outlined above, though there are many ways and means to tackle the issue, garbage issue is totally neglected one. As per the researcher's opinion there are certain problems, especially the waste treatment, has following issues.

Collection and Disposal of MSW:

The generated municipal solid waste in municipal areas is a daunting task for all municipalities due to poor implementation of solid waste management programme. No efforts for segregation of solid waste at the collection point, are tried and at the same time it is noticed that there is shortage of sanitary workers and lack of awareness among the citizens.

Anaerobic Digestion:

Biogas is a source of energy, one of the lowest relative carbon footprints of all; it is a very clean household fuel, producing mainly carbon-di-oxide and water. Contamination from plastic, sand, soil can reduce the efficiency of the plant, and also chemical contamination can compromise microorganisms.

Traditional Thermophific Composting:

In this process the problems are frequent tan ing of the material and loss of nutrients to some extent because of higher temperature for the prolonged time.

Vermicomposting:

Earthworms are very vulnerable to temperature change.They can be safe only at 28 degrees centigrade, + or - 2 degrees centigrade. In this particular process the executors cannot achieve the necessary pathogen kill temperature.

How to Resolve these Issues:

It is necessary to make a note of it that nearly 40% of domestic waste, 25% hotel waste, and 25% of commercial waste which is organic in nature can be segregated, collected and treated separately. BMC is having separate truck arrangement for hotels and commercial complexes but segregation is not done at source. Similarly in case of domestic waste, nearly 40% of the total waste, is not segregated at source and collected with dry waste.

Source reduction and source separation are important ingredients for sustainable municipal solid waste management. However, waste managers find it as a challenging task. This situation is more difficult in developing countries. Lack of public awareness, lack of environmental awareness and lack of public cooperation are the main barriers[6]. This can be handled effectively by awareness programmes and by implementation of MSW Rule 2000.

Anaerobic digestion in reality is a very appropriate system, in which methane is generated, captured and burnt. Methane is a greenhouse gas, 23 times more active than carbondioxide. This process should be run very carefully; otherwise it will spoil the environmental conditions.

Traditional thermophific composting:

The high temperature and long duration, some percentage of ntirients may get lost. The use of mechanical equipments and shredding of the organic matter will reduce the process time. The end material is not homogeneous, but it is free from pathogen.

Vermicomposting

Vermicomposting is a lengthy process, takes minimum sixty days. The final product is homogeneous and granular. The main disadvantage in this is that the final product may not be pathogen free and taking care of earth-worms is not easy.

Integration of thermophillic composting and vermicomposting can be a better choice, if processed simultaneously. Duration of the total process is about amonth and in the final product pathogens will be well within tolerable range.

Use of organic Waste for electricity generation is the clean and economical technology than ever before, including landfill gas capture, gasification etc.

Optiofls:

There may be a need of Revitalization of the total BMC's, MSWM system. This can include transfers, training of workers and staff for the service which they are rendering to the city. Management of MSW is to be revitalized for making strong decisions and implementations. More number of treatment plants may be required to be installed in 70 wards of

BMC. This will take care of inadequate capacity of treatment plants. This also will take care of stop gap arrangements in case of breakdowns.

Perspectives:

Reduce the Waste, Segregation at source:

As mentioned above, source reduction and source segregation are important ingredients for sustainable municipal solid waste management. (PanateManoma)[6]. This can be made possible by public awareness and public participation and by tightening the implementation of MSW Rule 2000. At source segregation is a failure in case of all municipalities, so centralised sorting system can be applied with the help of mechanical sorting facilities, using magnetic and electrical field separation, density separation, size separation and other techniques.

Efficient Collection:

After segregation, collection is rather easier. Then decide the proper schedule of lifting of dry and wet waste separately and divert truck load to the treatment site, before contamination.

Use of Organic Waste:

The processing of MSW for energy generation has become cleaner and economical technology than before, including combustion pyrolysis, plasma arc gasification etc. Incineration plants also emit high level pollutants.

Application of supply chain management, integrated municipal solid waste management and heading towards green economy may be the important strategy for waste free Bhopal city.

Conclusion:

The informal policy of encouraging the public to sepa- rate MSW and market it directly to the informal network appears to be a better option. The involvement of people and private sector through NGOs could improve the effi- ciency ofMSWM.Public awareness should becreated among masses to inculcate the health hazards of the wastes. Littering of MSW should be prohibited in cities, towns and urban areas notified by the state government. Moreover, house-to-house collection ofMSWshould be organized through methods like collection on regular pre-informed timing and scheduling. The collection bins must be appro- priately designed with features like metallic containers with lids, and to have a large enough capacity to accommodate20% more than the expected waste generationin the area, with adesign formechanical loading andun-loading, placement at appropriate locations, etc. Municipal author- ities should maintain the storage facilities in such a manner that they do not create unhygienic and unsanitary condi- tions.Proper maintenance oftheMSWtransportation vehicles must be conducted, and the Dumper Placer should replace the old transportationvehicles in a phased manner. Currently, at the level of waste generation and collection, there is no source segregation of compostable waste from the other non-biodegradable and recyclable waste. Proper segregation would lead to better options and opportunities forscientific disposal ofwaste. Recyclablescouldbe straightway transported torecycling units thatinturn would pay a certain amount to the corporations, thereby adding totheir income. This would help in formalizing the existing informal set up of recycling units. It could lead to several advantages such as enabling technology upgradation, better quality products, saving ofvaluable raw material resources of country, reducing the need for landfill space, a less energy-intensive way to produce some prod- ucts and employing labor in recycling industries. Organiz- ing the informal sector and promoting micro-enterprises are an effective way of extending affordable services. Pro- motion and development of recycling is a means of upgrad- ing living and working conditions of rag pickers and other marginalized groups.

Most of the MSW in India is dumpedon land in an uncontrolledmanner. Such inadequate disposal practices lead to problems that will impair human and animal health andresultineconomic,environmental andbiological losses. Comparing the biological, chemical and thermal treatment options in the Indian scenario, perhaps the bio- logical processing options get the priority. Composting and vermicompostingaresuccessful and quite popular now in India instead of incineration. But, it is slow process and requires a large space. An open dump or an uncon- trolled waste disposal area should be rehabilitated. Itis advisable to move from open dumping to sanitary landfill- ing in a phased manner. Landfilling should be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing.

The current regulations (MSWM rules, 2000) are very stringent. Norms have been developed to ensure a proper MSWMsystem. Unfortunately, clearly there is alarge gap between policy and implementation. Theproducer responsibility is to avoid having products on the market that cannot be handled effectively and environmentally cor- rectly when they become waste products. A new survey should be carried out on the generation and characteriza- tion of MSW in India. Since the MSW is heterogeneous in nature, a large number of samples have to be collected and analyzed to obtain statistically reliable results.

Finally, the study concluded that the lack of resources such asfinancing, infrastructure, suitable planning and data, and leadership, are the main barriers in MSWM. The increase of service demands combined with the lack of resources for municipalities are putting a huge strain on the existing MSWM systems.

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Table 2
Physical characteristics of MSW in Indian metrocities

Characteristics (% by weight)								
Name of metrocity	Paper	Textile	Leather	Plastic	Metals	Glass	Ash, fine earth and others	Compostable matter
Ahmedabad	6.0	1.0	–	3.0	–	–	50.0	40.00
Banglore	8.0	5.0	–	6.0	3.0	6.0	27.0	45.00
Bhopal	10.0	5.0	2.0	2.0	–	1.0	35.0	45.00
Mumbai	10.0	3.6	0.2	2.0	–	0.2	44.0	40.00
Calcutta	10.0	3.0	1.0	8.0	–	3.0	35.0	40.00
Coimbatore	5.0	9.0	–	1.0	–	–	50.0	35.00
Delhi	6.6	4.0	0.6	1.5	2.5	1.2	51.5	31.78
Hyderabad	7.0	1.7	–	1.3	–	–	50.0	40.00
Indore	5.0	2.0	–	1.0	–	–	49.0	43.00
Jaipur	6.0	2.0	–	1.0	–	2.0	47.0	42.00
Kanpur	5.0	1.0	5.0	1.5	–	–	52.5	40.00
Kochi	4.9	–	–	1.1	–	–	36.0	58.00
Lucknow	4.0	2.0	–	4.0	1.0	–	49.0	40.00
Ludhiana	3.0	5.0	–	3.0	–	–	30.0	40.00
Madras	10.0	5.0	5.0	3.0	–	–	33.0	44.00
Madurai	5.0	1.0	–	3.0	–	–	46.0	45.00
Nagpur	4.5	7.0	1.9	1.25	0.35	1.2	53.4	30.40
Patna	4.0	5.0	2.0	6.0	1.0	2.0	35.0	45.00
Pune	5.0	–	–	5.0	–	10.0	15.0	55.00
Surat	4.0	5.0	–	3.0	–	3.0	45.0	40.00
Vadodara	4.0	–	–	7.0	–	–	49.0	40.00
Varanasi	3.0	4.0	–	10.0	–	–	35.0	48.00
Visakhapatnam	3.0	2.0	–	5.0	–	5.0	50	35.00
Average	5.7	3.5	0.8	3.9	1.9	2.1	40.3	41.80

Source: Status of solid waste generation, collection, treatment and disposal in metrocities, (CPCB, 2000).

Table 3
Physical characteristics of MSW in Indian cities population wise

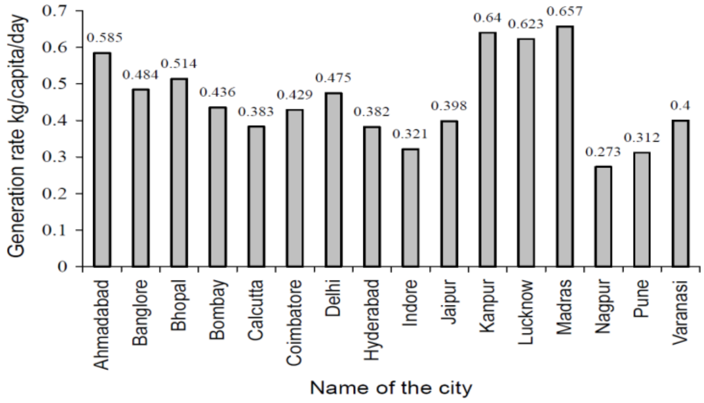
Population range (in million)	No. of cities surveyed	Paper	Rubber, leather and synthetics	Glass	Metal	Compostable matter	Inert material
0.1–0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5–1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0–2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0–5.0	3	3.18	0.48	0.48	0.59	56.57	49.07
5.0 and above	4	6.43	0.28	0.94	0.8	30.84	53.9

All values are in percentage and are calculated on wet weight basis.
Source: NEERI report strategy paper on SWM in India, August 1995.

Table 4
Chemical characteristics of MSW in Indian cities population wise

Population range (in million)	Nitrogen as total nitrogen	Phosphorus as P_2O_5	Potassium as K_2O	C/N ratio	Calorific value kcal/kg
0.1–0.5	0.71	0.63	0.83	30.94	1009.89
0.5–1.0	0.66	0.56	0.69	21.13	900.61
1.0–2.0	0.64	0.82	0.72	23.68	980.05
2.0–5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

Source: NEERI report strategy paper on SWM in India, August 1995.



ig. 1. Per capita generation rate of MSW for Indian cities (CPCB, 2004).

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.5, pp : 467-473 1 May 2014

Table 1
Municipal solid waste generation rates in different states in India

S. No.	Name of the state	No. of cities	Municipal population	Municipal solid waste (t/day)	Per capita generated (kg/day)
1	Andhra pradesh	32	10,845,907	3943	0.364
2	Assam	4	878,310	196	0.223
3	Bihar	17	5,278,361	1479	0.280
4	Gujrat	21	8,443,962	3805	0.451
5	Haryana	12	2,254,353	623	0.276
6	Himachal pradesh	1	82,054	35	0.427
7	Karnatka	21	8,283,498	3118	0.376
8	Kerala	146	3,107,358	1220	0.393
9	Madhya Pradesh	23	7,225,833	2286	0.316
10	Maharashtra	27	22,727,186	8589	0.378
11	Manipur	1	198,535	40	0.201
12	Meghalaya	1	223,366	35	0.157
13	Mizoram	1	155,240	46	0.296
14	Orissa	7	1,766,021	646	0.366
15	Punjab	10	3,209,903	1001	0.312
16	Rajasthan	14	4,979,301	1768	0.355
17	Tamil Nadu	25	10,745,773	5021	0.467
18	Tripura	1	157,358	33	0.210
19	Uttar Pradesh	41	14,480,479	5515	0.381
20	West Bengal	23	13,943,445	4475	0.321
21	Chandigarh	1	504,094	200	0.397
22	Delhi	1	8,419,084	4000	0.475
23	Pondichery	1	203,065	60	0.295