Review of Present and Future Community Solid Waste Management,its effect and resource potential in selected wards – A case study of Bruhat Bangalore MahanagaraPalike

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Abstract

Managing municipal solid wastes (MSW) is increasingly becoming a major challenge in many cities of developing countries because of increasing in population growth and rapid urbanization. The main objective of the municipal authorities in the country to keep cities clean by providing basic essential services for solid waste management. Due to industrialization, rural to urban resettlement and high population growth have provoked rapid urbanization in developing countries and especially in India also. The per capita waste generation rate in India has increased from 0.48 kg/day in 2002 to 0.52 kg/day in 2013. Such a sudden changes in waste generation within a decade has severed the stress on all infrastructural, natural and budgetary resources. Bangalore city is one of the fastest growing city, it generates total quantity of waste is about 3500 tons per day. The present study illustrate the current state of municipal solid waste management in selected wards of Bangalore city, its associated overview with focus on different aspect of Community Solid Waste Management (CSWM) such as collection and disposal, recycling, identifying the main problems and limitations that hinder improvement in the current MSWM practices. The information collected from BBMP personal with varying responsibilities within the system. Similarly, photograph, documentation, field and direct observation were considered in this research work. A field work that involves characterization and classification of the waste generated and frequency of collection was carried out. Four wards were selected for the study and the major and unknowingly dumping places are located within the wards were considered. In current context, inselected wards like RadhakrishneTemple, Sanjay Nagar, Ganga Nagar and Hebbal of Bangalore city approximately 15.82, 16.57, 13.81 and 16.60 tons of solid waste generated each dayand the total waste generation rate is 0.42 kg/ capita/day respectively. The physical composition of the produced solid waste consists of 62% of the wastes are recyclable with lots of organic waste that can be used as compost, vermicomposting and bio-methnation process.18% is contains plastic waste other 20% includes the other waste like metals, building demolished waste. The study revealed that there is presently the collected waste are segregated as biodegradable and plastic waste. The biodegradable materials are using for using for composting, the plastic waste using for manufacturing plastic pipes. The study suggests along with present technology new approach that could be used by institutions, government agencies and also non-government organizations for municipal solid waste management to realize a sustainable and efficient sanitation.

INTRODUCTION

Solid waste management (SWM) is a major public health and environmental concern in the urban areas and many developing countries. Solid waste is also considered as community solid waste (CSW) which is also termed as Municipal Solid Waste (MSW). The situation in developing countries, especially in India, particularly in the large urban towns is severe. The public sectors in many countries are unable to deliver services effectively, regulation of the private sectors is limited and illegal dumping of domestic and industrial waste is a common practice. Local authorities charged with the responsibility of providing municipal services have found it increasingly challenging to play this role (UNEP, 2010).

Community solid waste includes discarded and unwanted substances household, street sweeping and commercial and industrial operations. Increase in urban population, modern technology also changing lifestyles lead to the generation of solid waste. Generally, solid waste is a non-homogeneous and also intrinsic property in nature such as mixture of vegetables, food items, paper, plastics, rags, glass etc. If solid waste is disposed directly on land and in open areas, then it causes a negative impact on the environment, mantle layer of the earth and on human health. The management of solid waste directly related to human activity and directly impacts the health of the people and surroundings (Vergara, 2012). Due to improper management of solid waste and common problems associated with diseases includes unwanted odor, fire hazards, gaseous and aquatic pollution, irritation and economic losses (Jilani, 2002).

Currently in India most of the municipal waste is being disposed unscientifically (Akolkar, 2005). Generally community solid waste is collected and dumping in open and unscientific disposal attract pigs, birds, rodents and fleas to the waste site and surround become pollution (Suchitra, *et al.*, 2007). The degraded solid waste is discharges carbon dioxide (CO_2), methane (CH_4) and other trace gases. The dumping of solid waste unscientifically on land site may affect the quality of the groundwater which are used for drinking water and causes the disease like nausea, jaundice, asthma etc (Bean, *et al.* 1995). Babayemi and Dauda (2009) noticed that due to the lack of technical expertise, inadequate separation technology, weakness of solid waste management guidelines and compliance by people, environmental awareness and earnings of people among others, are reasons for inefficient waste management.

As per literature during 2009 total solid waste generation is 3000 tons per day and the population is 78 lakhs, currently, nearly4000 tons/day of community solid waste is generated in Bangalore city due to increase in population and household. The generation of community solid waste is direct relationship between environmental, economic and technological factors. Bruhath Bengaluru MahanagaraPalike (BBMP) is responsible for collection, storage, segregation, transportation and disposal of all solid waste generated in the town. This research work describes an attempt to assess the collection, segregation, transportation, treatment and disposal of BBMP land fill site and also focuses on understating effective waste management practices in selected wards. The present work also provide a comprehensive review of CSWM Practices in Bangalore.

MATERIALS AND METHODS

Study Area

Bangalore lies at having latitude $13^0$02'00.90``N and longitude $77^0$34'32.17``E. covering an area of 800 Sq.km. Bangalore is the planned city in India with a population of 8.4 million in 2011. Bangalore is the fifth most populous city in India and the 18^{th} most populous city in the world. Bangalore was the fastest-growing Indian metropolis after New Delhi between 1991 and 2001, with a growth rate of 38% during the decade. The entire management of solid waste is taken care by Bruhath Bengaluru MaganagaraPalike (BBMP). The corporation of the city is making efforts to devise plans and strategies for management of solid waste in an efficient manner.

Methodology

The data collection involved collection of topographical maps, ward maps and demographic details. The environment of these data and their source are shown in Table 1. The Survey of India topographical maps scale 1:50,000 was used for the current study of the following features: drainage, water bodies, contours, roads and rail network and administrative boundaries. Other data sources are satellite images of Bangalore city, various maps collected from secondary sources. Discussion and interviews were held with some of the residents, scavengers and key officials in order to confirm the practice and problems facing solid waste management.

Table 1 Primary and secondary data details

Segment : Bangalore Town	Sources
Top sheet No	D43R12 Survey of India
Google Image	Internet
Geological map	Geological Survey of India, Bangalore
Demographic details from Primary census abstract for 2001 and 2011	Directorate of census operations, Census of India
All Secondary data related Solid Waste Management, Land use/Land cover etc.	BBMP, Bangalore
Ward maps and Administrative Boundary	BBMP, Bangalore

This study employed a descriptive cross-sectional design that was conducted between April and August 2015 (Five Months). The Bangalore City Administration is sub divided into 198 administrative wards. In the present study four wards (Figure 1) were selected based on the population like Ward No 18 is Radhakrishna temple (RT), No 19 is Sanjay Naga (SN), No 20 is Ganga Nagar (GN) and No 21 is Hebbal (HB) of BBMP, Bangalore, with an area of 1.9 Sq.km, 1.5 Sq.km, 2.3 Sq. km and 1.2 Sq.km respectively. It is observed that Bangalore city generates dry and moisturized waste approximately in ¼ proportions (i.e. 70% and 30%). Finally questionnaires were administered to the selected households from the four chosen wards. The projected population of the selected wards in Bangalore city based on the 2011 national census is **1,27490.** Total 150 representative households from the selected 04 wards systematic sampling based on the earlier researchers was used (Vikrant Tyagi, *et al.*, 2014).

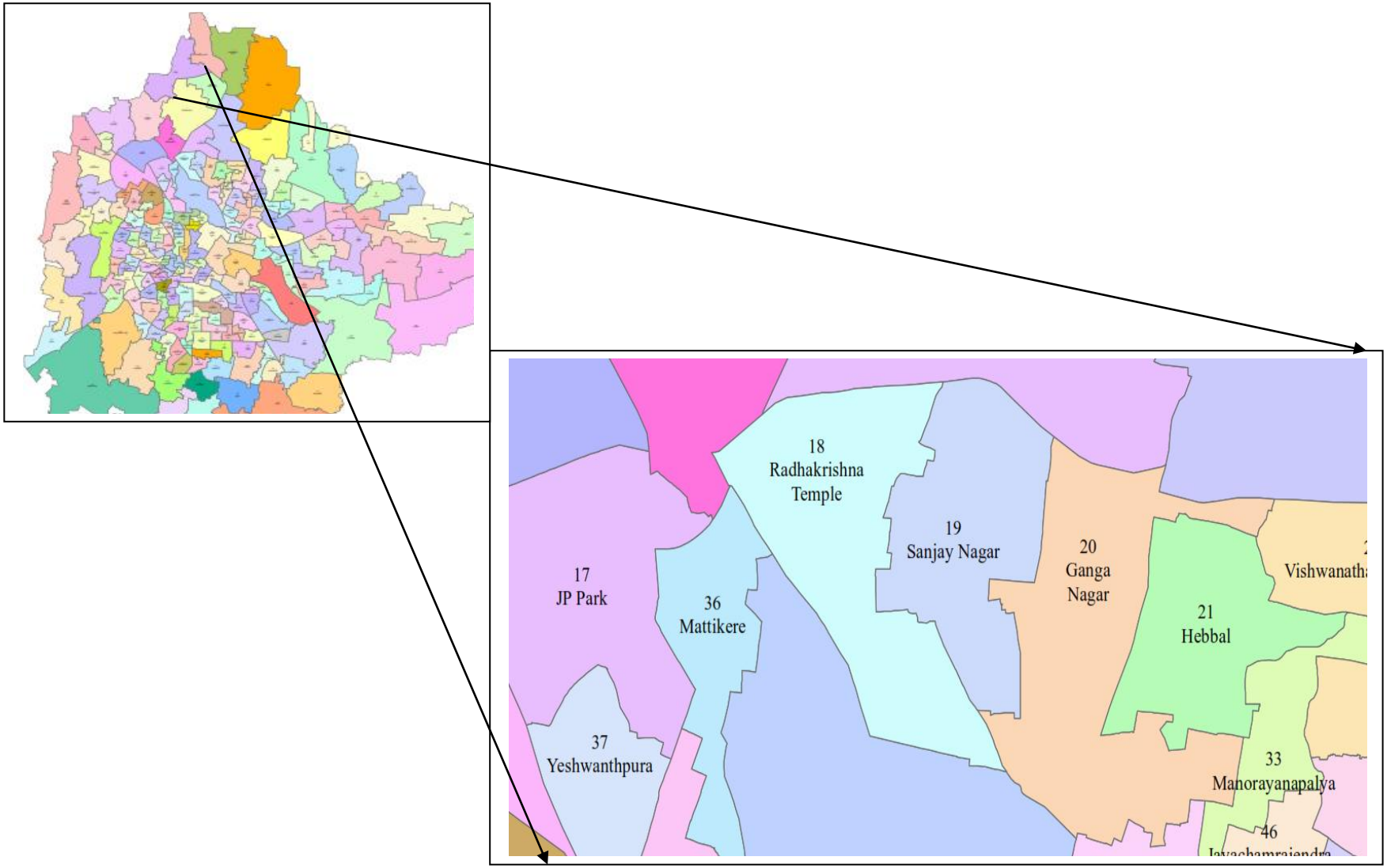

Figure1A Mapof Bangalore showing selected wards ofthe study area

The total area of the selected ward in Bangalore is 690 hector of land. The housing units were marked in each wards in order of their serial number like house number 1, 2, 3, 4 and so on. The total number of housing units in the selected in each ward was 150. To determine the total sample size, the common method adopted is to use 5% of the total population and systematically selected for the distribution of the questionnaire. Apart from questionnaire, interviews and focus group discussions were conducted with concerned municipal authorities of BBMP (Manaf, *et al.*, 2009).

As per the standard method, community solid waste broadly categorized into three groups, Biodegradable, Recyclables and static. Biodegradables consist of kitchen wastes and food waste. Recyclables are included paper, plastic, glass and metal. About 45 per cent of the waste is generated from domestic waste, followed by hotels, restaurants and other commercial establishments which together account for over 50 per cent of the waste generated. The selected wards for present study were given in Figure 2.

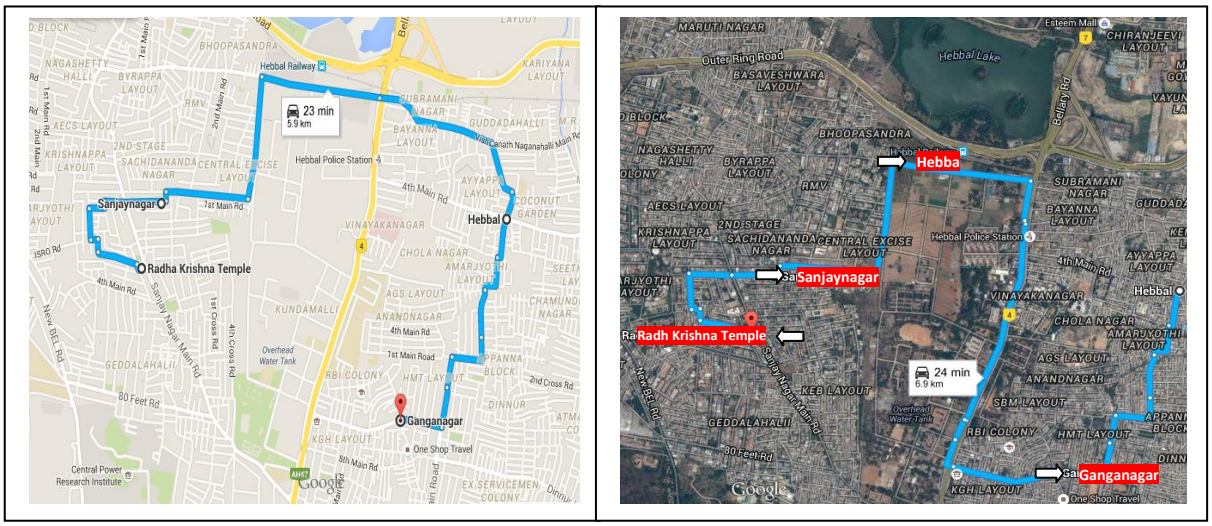

Figure 2 A Google map of Bangalore showing selected wards and locations of the Waste collection point

RESULTS AND DISCUSSION

Municipal Solid Waste (MSW) generation and composition in selected wards of BBMP

Waste generation, waste handling and separation, storage and processing, collection and transport, and final disposal are some of the important practices done for sound solid waste management (Parag S. Dawane and Sagar, 2015 and Tchobanoglous,1993).

Managing Municipal Solid waste in selected wards of Bangalore is handled by BBMP as similar in India and other states. The major sources of solid waste include waste from residence, commercial activities, institutions, markets and hospitals. The detailed of Community Solid Waste (CSW) generation from different sources with percentage is presented in Figure. 3. The majority of daily waste is produced from the domestic (50%) and the rest of the sources like, hotels, market area and commercial including street cleaning have contributed to 50%.

From the present analysis, in selected wards like Radhakrishne Temple, Sanjay Nagar, Ganga Nagar and Hebbal of Bangalore city approximately 15.82, 16.57, 13.81 and 16.60tons of solid waste generated each day and the total waste generation rate in 18, 19, 20 and 21 wards is 0.42 kg/capita/day (Table 2) respectively. In general, the projection of population growth in the municipality by 2025 is 2.9 million with MSW generation per capita of 0.55kg/capita/day (World Bank, 2012). Urban population growth is the direct relationship with the increase of municipal waste generation (Achankeng, 2003). Study by Biubwa Ally, *et al.,* (2014) in Zanzibar reported that by rapid urbanization caused by rural to urban migration has increased the waste generation. The same trends were observed by Okot-Okum (2012) in East African Cities.

The meancommunity solid waste generation rate households' solid waste in selected wards in Bangalore was 0.42kg/c/day. The collected data reveals the average total community solid waste generation rate in selected wards of Bangalore is below 0.55 kg/capita/day. The community solid waste composition of Bangalore city is given Figure 3. The present study can say that solid waste generation rate in selected wards shows that low and medium income families are living and is waste generation is lower, when it compared to other researchers investigation. Melaku T. (2008) and MengieBelaynehTiruneh, (2005) indicated in their work, Addis Ababa 0.253kg/c/day, Bujumbura 1.4kg/c/day, Lome 1.9kg, Abuja 0.4kg/c/day (Asnani, 2006). As Ciontreau (1982) pointed out that, solid waste generation rate is directly related with income and solid waste

generation rate for low-income 0.4 to 0.6 kg, middle-income 0.5 to 0.9 kg, and high-income 0.7 to 1.8 kg per capita per day. However, the present study reveals that the solid waste generation in selected wards of Bangalore is less than the findings of Ciontreau i.e. high, middle, and low income group of the sample households in Dessie town are 0.282, 0.247, and 0.184 kg/c/day respectively.

Tchobanoglouset, *et al.*, (1993) and Khatib. I.A, (2011) indicated in their work, the low income country produce more food waste than paper because they cook their own food, while higher income country do not cook. Also food waste are lower in high income country because of improved food processing techniques and the increased use of food waste grinders, hence relatively high plastic and paper for food packaging characterize their waste stream. The present investigation also coincide with the above mentioned findings.

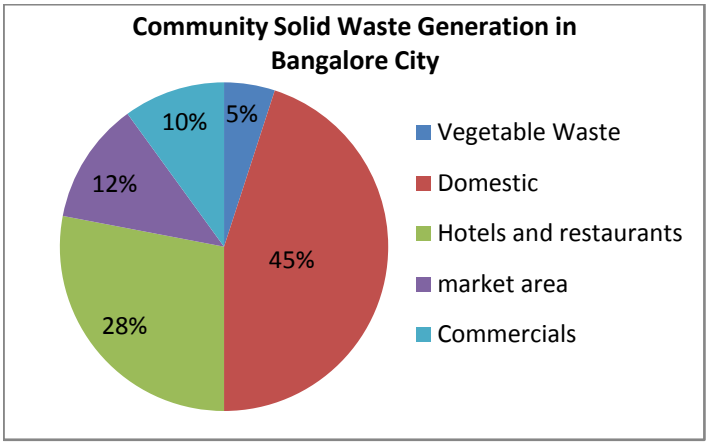

Figure 3 Sourcesof Community Solid Waste Generationin selected wards of Bangalore City

Projected Population in selected wards.

The average decadal population growth in selected wards of Bangalore from 2001-2041 is 8.28 %. The estimated growth rate by 2041 would be 7.47 percentages. Projected population of selected wards and daily waste generation rate is given in Table 2.

Table 2 Projected populations of selected wards, growth rate and decadal growth rate

Ward	Population 2011	Population 2015 (projected)	Per capita rate (kg/c/day)	Daily generation Tonnes/day
R K temple	35122	37685	0.42	15.82
Sanjay Nagar	32491	39472	0.42	16.57
Ganga Nagar	27361	32882	0.42	13.81
Hebbal	32516	39505	0.42	16.60
Total	**1,27490**	**149544**	**0.42**	**62.80**

Results in Table 3Composition of community solid waste quality,shows that a largerproportion of the communitywaste generated by the people of Bangalore is inorganic which is relatively the similar over the entire sampling points. In the present study, highest food waste generated in Sanjay Nagar ward but lowest in Radhakrishna temple ward. These data informed on the kind of materials used mostly by the inhabitants. These wastes all have potential for recycling if they are all sorted out from the source as done in developed nations. Table 4 indicates that food waste takes a significant amount of the organic waste stream, which when used appropriately could be of great benefit in composting. The remaining decomposed waste stream if annexed could be used to generate biogas or could serve as an alternative energy source. Present study also agreement with results reported by many authors such Ethiopia (Vikrant Tyagi, *et al.*, 2014) Indonesia (74%) (Walhi, 2001); India (42%) (Ahkolkar, 2001); Turkey (43-64%) (Metin, *et al.* 2003); and Nigeria (52-65%) (Imam, *et al.*, 2008).

Table 3 Composition of solid waste in selected ward of Bangalore

Ward	Quantity kg	Food, market waste, animal excrements, garden waste	Fine earth (ash, dust, soil) and Other Waste	Metals, Glass and ceramics	office paper, bills, paper box, cardboard, newspaper, magazine and mixed paper	PET, HDPE, PVC, LDPE, PP, PS containers
R K temple	240	48.79	10.25	6.02	6.52	28.42
Sanjay Nagar	245	51.68	8.92	5.98	7.01	26.41
Ganga Nagar	240	49.85	9.89	5.89	6.54	27.83
Hebbal	250	52.83	12.01	4.71	5.03	25.42

Table4CompositionofOrganic and inorganic waste inselected wards of Bangalore

Locations	Hebbal Division			
	R K temple	Sanjay Nagar	Ganga Nagar	Hebbal
Organic %	48.79	51.68	49.82	52.83
Paper %	6.52	7.01	6.54	5.03
Plastic & Rubber %	28.42	26.41	27.83	25.42
Metals & Glass	6.02	5.98	5.89	4.71
Fine Earth	7.21	6.82	7.25	9.21
other	3.04	2.1	2.64	2.8

Primary Collection: Present investigation reveals, about 108 sweepers were employed in selected wards by BBMP for primary waste collection street sweeping from households. Each sweeper is responsible for the daily cleansing of a fixed area, (length range) usually at both sides of street lanes. Each sweeper working between 6.00 a.m. and 9.00 am about 5 hour an average. BBMP adopted several method of cleaning to collect the community waste generated from households and road side thrown waste, such as door to door collection, street sweeping, using vehicles and small auto tippers. In India most of the cities adopted a common method for primary collection of waste deposited in the streets.

Secondary Collection and Transportation: Transportation and secondary collection of MSW from the variouscollection points to disposal sites in Municipalities is commonly done by Municipalities workers using hand push carts, tri-cycles, auto tippers, lorry, tractor and trailer, depending on their availability and the nature/quantity of the MSW. Present study also supports to transport the secondary collected MSW by BBMP.In selected wards out of 72 vehicles operating 53auto tippers for waste transportationincluding 1 compactor each 8 MT and 6tipper Lorry with each 6 MT capacities, 2 MiniLorries with each 4 MT capacities.The municipality workers have been provided with the protective gears such as hand gloves, shoes and masks. Each earth moving vehicles have performing 2 rounds in the morning upto 10.00 AM and after that entire waste transported to the dumping yard.

The present findings in the selected ward of Bangalore indicates, there are 156 pushcarts for sweeping and 34 pushcarts for open area cleaning were used, The commercial market waste is directly collected in compactor from large heaps accumulated in front of the all markets and transported to the dumping yard without segregation. The details of the vehicle for waste

transportation in selected wards in Bangalore is given in Table 5.

Table 5Use ofVehicles forWasteTransportation in selected wards of Bangalore

	R.K Temple	Sanjaynagar	Ganganagar	Hebbal
Auto Tipper (Small and Big)	16	15	17	15
Pushcarts door to door collection	4	3	4	3
Compactor	1	2	--	--
Tipper Lorry	1	3	2	2
Pushcarts street sweeping	38	34	45	39
Push Carts open area cleaning	6	6	12	10

From the table 5 it is clear that 21.33 population of selected wards in Bangalore disposed waste illegally into public places and ditches.Fewer households of selected wards (10.67%) reported that BBMP practiced burning of the waste in some parts of the city and also in the dumping yard to get exonerate the collected waste (Figure 4). Such practice poses high risk on the local environment. Improper solid waste management causes all types of pollution: air, water and soil. Mor, *et al.*, (2006) and Vikrant Tyagi, (2014) reported in their work, indiscriminate dumping of solid wastes contaminates surface and ground water supplies.

Disposal Methodology

In the present investigation and concluded that still open dumping of the waste is the most prevailing activity practiced by BBMP when it comes to final disposal of waste, making high probability of environmental pollution. Table 6 reflects the different methods of dumping of solid wastes practiced by BBMP of the selected wards.

Table 6 Types of Disposal methods in practice in Selected Wards in Bangalore

Sl No	Disposal Methods	No. of Respondents		Remarks
1	Public Open Space	32	21.33%	Illigal
2	Aerobic Composting Vermicomposting	80	53.34%	Legal
3	Burning	25	14.67%	Illigal
4	Biomethanation	16	10.67%	Legal

Figure 4 Community waste throwing nearby areas in the selected wards

Collected waste from remaining 53.34% of the respondents is transported to dumping site by BBMP. A total 11 vehicles are available for transportation of waste in selected wards. If the only 11 vehicles are assigned only for waste disposal by the municipality rather than other added activities, there are sure chances that area covered by municipality for collection, transportation and disposal of waste will significantly increase from the present 53.34%.

BBMP is responsible for the transportation of collected wastes to dumping site, which is a plain land instead of landfill site. The Community solid waste is dumped on land, more or less in an uncontrolled manner, as practiced in majority of cities in other developing countries (Zurbbrug, 1999) and Vikrant Tyagi, (2014).

Present problems and challenges linked with CSW management

Proper disposal and management of municipal solid waste is one of the challenging tasks faced by the BBMP. The main factors for miscarriage of solid waste management in accordance with the principle of public health, environmental protection, socio-economic and aesthetically.

From the present investigation, during the last few years in selected wards population has beenincreasing and so the amount of waste generated. With growing in these selected wards population BBMP fails toprovide service to all households, as a result currently BBMP is facing challenges in providingefficient municipal solid waste management. Despite the legal provisions existing for proper handling and management of MSW there is lack of implementation.

Currently BBMP dumping the solid waste away from the Bangalore. The collected community solid waste is transported to dumping yard, manually separated plastic and other waste from collected community solid waste. The separated organic waste and inorganic from the selected wards is using for composting and manufacturing of pipes respectively is given in Figure 5. The current treatment methodology adopted for dry community solid waste from selected wards is by vermicomposting and biomethanation by M/s Ramky industries (600 MTPD) and aerobic composting by M/s Terafirma (1000MTPD).

Figure 4 Community plastic waste is used for manufacturing of pipes in dumping yard

CONCLUSION

Solid waste generation in selected wards in Bangalore city is not as such greater than other areas of the world and cities and towns in Mumbai (0.35kg/c/day). But the way peoples manage it is the critical problem. The growth of solid waste in selected areas of Bangalore is increasing from time to time due to different aspects. Therefore, from the findings of the study it can be concluded that solid waste generationof a household is mainly the function of income and family size.

The increasing solid waste may beas the household income increases consumption pattern and consumption levels increases directly leads to high solid waste generation. Community solid waste management (CSWM) remains a major public health and environmental concern in selected wards of Bangalore city in general. Therefore, Community solid waste management facilities should be expanded and other waste reduction strategies should be implemented.

Recommendations

Based on the investigation of the study the following recommendations are forwarded:

- Community solid waste generation is directly related with the income and population size, facilities (including collection, transportation, number of containers and collection centers, work force, budget etc) should be expanded proportionally from year to year and additionally other waste minimization technologies should be implemented.
- Since, the existing solid waste disposal yard is poorly designed and it is for away from the selected wards. Therefore, try to provide solid waste treatment unit nearby wards and can select appropriate solid waste disposal site for the town using GIS with its multi criteria.

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