

Municipal Solid Waste Management System: A Study on Dhaka North and South City Corporations

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Abstract

Generation of municipal solid waste is ominously increasing due to the rapid growth of population coupled with the increasing scale of economic activity, i.e. urbanization, industrialization, and improved living standards. Urban local bodies across the world are struggling with the tenacious problems of municipal waste management, particularly in disposal of waste. Based on estimates, two Dhaka city corporations collectively generate about 1.6 million tons of municipal waste each year and emit approximately 1 million tons of GHG. This paper aims to evaluate the capacity of Dhaka North and Dhaka South City Corporations in handling waste against the mounting generation of MSW. The entire study is developed with secondary information but substantial primary information has been collected to update and to verify the information received from secondary sources.

Introduction

Bangladesh is the eighth most populous (World Population Review, 2015; World Atlas, 2015) country with the population of 158.36 million as of 20 April, 2015 (BBS, 2015) and the fifth most densely (World Atlas, 2015; Wikipedia, 2015) populated country in the world having 1015 persons living in sq. km (BBS, 2011). Like other countries, Bangladesh is also facing similar adversity as the amount of waste generated from domestic and commercial activities is increasing day-after-day in the large cities including the mega-city Dhaka (DoE, 2013). A study by Department of Environment (DoE) revealed that Dhaka's problem regarding solid wastes is worse compared to cities in other developing countries (DoE, 2013). According to the UNFPA report, Dhaka is one of the most polluted cities in the world and one of the concerning issues is the poor management of municipal waste (Bhuiya, 2007:29). Alamgir and Ahsan (2007) estimated a total of 7690 t of MSW generated daily in the six major cities (namely, Dhaka, Chittagong, Khulna, Rajshahi, Sylhet, and Barisal), while the Dhaka city contributed the most (69%, 5340 t) to the total waste stream. Rahman, et al., claimed that the waste in Dhaka comprises mainly 60% of organic waste which can produce landfill gas (methane) upon decomposition. Their observation from the GHG emission calculation on the basis of IPCC Guideline tier-1 revealed that 20.5 Gg and 16.96 Gg methane are emitted from the landfill sites at Dhaka City against 1670 ton and 1375 ton municipal solid waste in 2005 and 2001 (Rahman et al., 2013). Chowdhury, et al. (2014) assessed Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) collectively generate about 1.6 million tons of municipal waste per year which emit approximately 1 million tons of GHG annually. These increasing rates of MSW create an adverse effect on environment as well as social and professional life of city residents, urban planners, developers, and other concerned stakeholders (Alamgir et al., 2005).

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Methodology

Regarding solid waste management of DNCC and DSCC, primary information have been collected from key informants of respective city corporations, while some secondary information are gathered from previous studies. Municipal solid waste has been collected from twenty different locations (eighteen secondary collection points and two permanent land filling sites) of DNCC and DSCC through Site *Sampling*. Physical properties of the collected MSW have been analyzed manually in the R&D lab of Institute of Appropriate Technology (IAT), BUET. Physical analysis of municipal solid waste therefore has been carried out to estimate the share of organic and inorganic materials in waste stream.

Background of Dhaka North and Dhaka South City Corporations

Dhaka, the capital of Bangladesh is ranked ninth among the megacities of the world (UNESCAP, 2009) having more than 55,500 people per sq. km (UN-HABITAT, 2013) that ultimately makes Dhaka the most densely populated city in the world. Forbes (2013) estimated in 2013, population of Dhaka is nearly 14.4 million within its city area of 165.63 sq. km (UN-HABITAT, 2013). The population of Dhaka city has increased rapidly, with a growth rate of 3.72% per year (Islam, 2003). Every day 10% of total population migrates to Dhaka for different activities (Rahman et al., 2013). Dhaka City Corporation was first established as the Dacca Municipality on August 1, 1864. It gained status as Dhaka Municipal Corporation in 1978 and it was renamed as Dhaka Municipal Corporation in 1983. Finally, in 1990, it was named again as Dhaka City Corporation (DNCC, 2014a). In late 2011, by the Local Government (City Corporation) Act' 2009 (Amendment in 2011), Dhaka City Corporation was divided into Dhaka South City Corporation (DSCC) and Dhaka North City Corporation (DNCC) for administrative convenience.

Dhaka North City Corporation (DNCC) is situated in the northern part of Dhaka City which consists of 36 wards. The total area of DNCC is about 75 sq. km (Field Survey, 2015). On the other hand, Dhaka South City Corporation (DSCC) consists of 57 wards within its 42 sq. km area (Fig-1).

Current State of Municipal Solid Waste (MSW) in Dhaka City

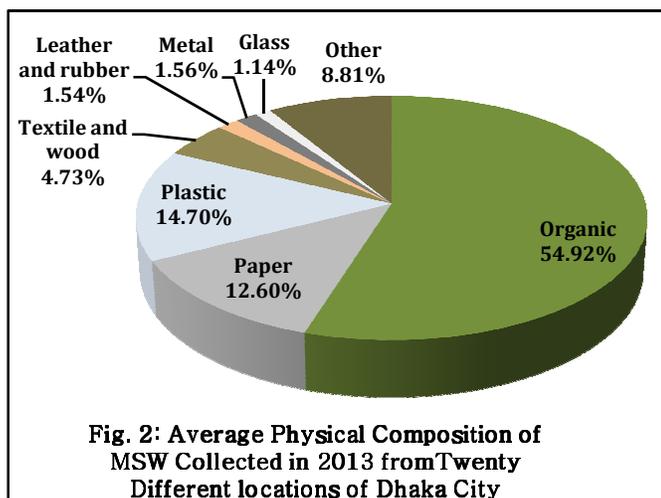
Based on the total estimated urban population of 2005, Waste Concern Study (2005) assessed that total waste generated in Dhaka was about 4,634.52 tons/day accumulating to over 1.69 million tons/year. Moreover, a JICA study revealed that during the wet season, the rate of waste generation increases by 46% (Enayetullah et al., 2005). Alamgir and Ahsan (2007) estimated that waste generation rate is ranging from 0.325 to 0.485 kg/cap/day, while highest rate is 0.485 kg/cap/day in Dhaka City. They also reported that about 78% solid waste is coming from residential sector and 20% from commercial sector, 1% from the institutional sector and rest from other sectors. The average waste generation rate from domestic source proved to be 0.34 kg/cap/day (JICA, 2005). High moisture content and low calorific value characterized the solid waste properties in Dhaka City as observed by Yousuf and Rahman (2007). Over time, municipal solid waste is not only increasing but the composition is also changing. The organic wastes are decreasing and the paper and plastics are increasing in the waste stream, indicating the growing preference for consumption of packaged food in recent years (Yousuf and Rahman, 2007).

Baseline Composition of Collected Solid Waste

The average waste composition for the entire waste stream in Dhaka city has been estimated from field survey (2013) and is presented in Figure-2. As compared to other fractions, the biodegradable fraction (organic matter) is normally very high, which was about 55%. The share of other fraction combined from all locations was about 14.7% plastic, 12.6% paper, 4.73% textile and wood, 1.54% leather and rubber, 1.56% metal, 1% glass and ceramics, and 8.81% other waste.

Waste Composition in Dhaka City Found in Different Studies

Several studies have been conducted by different authors to determine the composition of MSW generated in Dhaka city. Table-1 shows a comparison of the present study with different studies conducted earlier on municipal waste composition. As reported in the previous studies, organic matters varied over a wide margin ranging from about 62% to 88% during 1993-2005 in Dhaka city whereas, paper and plastic varied from about 1% to 11% and 1% to 7% respectively (Alamgir and Ahsan, 2007).



Waste Management Practice in DNCC and DSCC

The erstwhile Dhaka City Corporation had been working to improve the overall solid waste management of Dhaka city with the technical assistance of the Japan International Cooperation Agency (JICA) in 2000. A master plan on solid waste management titled *Clean Dhaka Master Plan* was formulated in 2005 and included a target year of 2015 to make the city of Dhaka clean (JICA, 2005). The master plan stressed on public awareness raising, primary collection, secondary collection, transportation and final disposal as well as administration and financial management. For the implementation of Clean Dhaka Master Plan, a technical cooperation project consisting of the dispatch of experts started in February 2007 and completed in February 2011 implemented by then DCC and JICA Expert Team (JICA, 2012).

Both the DNCC and the DSCC collect municipal wastes which are accumulated in corporations' bins or containers. Table 2 presents basic information of solid waste management at Dhaka North and Dhaka South City Corporations. From that table it can be seen in June 2012, total waste generation amount estimated for the DNCC was about 2186 tons/day and for the DSCC was about 1938 tons/day. The table also reveals that the DNCC was able to collect about 1100 ton of waste/day in June, 2012 whilst the waste collection capacity of the DSCC at that time was about 1400 tons/day.

Table 2: Basic Information of Solid Waste Management at DNCC and DSCC

Items	DNCC	DSCC
Number of Zones	5	5
Number of Wards	36	57
Waste Generation Amount (June, 2012)	Approx. 2186 t/day	Approx. 1938 t/day
Waste Collection Amount (June, 2012)	Approx. 1100 t/day	Approx. 1400 t/day
Waste Disposal Site	Amin Bazar	Matuail
Area of Disposal Site	20 hectare	40 hectare
No. of Ward SWM Offices	7	10
Number of Waste management Officials	257	352
Workshop	At Dholpur	

Source: Information collected by Field Survey (2015) from WMD of the DNCC

Waste Management Department of the DNCC and the DSCC

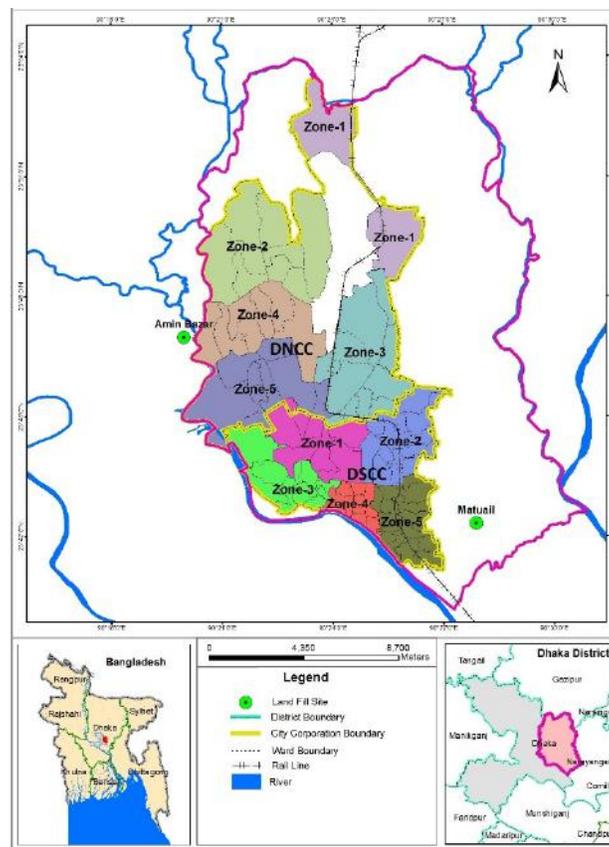
Previously, each component of Dhaka's solid waste management system was implemented by separate government offices. Very recently a Waste Management Department has been formed in the light of the *Clean Dhaka Master Plan* to oversee waste operations. The Waste Management Department ultimately became responsible for solid waste management and is in charge of street and drain cleaning, carrying street and drain waste to dustbins/containers, and loading and unloading of waste to and from truck at places of dustbins/containers and disposal sites. Establishment of Waste Management Department aims at integrated solid waste management by one department with a unified chain of commands. With coordinated annual operation plans and budgets, effective and efficient solid waste management can be achieved. With one department, integrated management throughout waste stream, from waste generation to final disposal can be realized (DNCC, 2015). Both the Waste Management Departments of DNCC and DSCC comprise a predominant portion of field workers and very few officers for planning and administration at headquarters. After inception, following functions are going on under the Waste Management Department of the DNCC and the DSCC:

- Ward conservancy activities
- Provide dustbins and other receptacles for accumulating the waste
- Giving permission to PCSP (Primary Collection Service Provider) for door to door waste collection from household by van services

- Skill development program for primary waste collectors
- Establishment of secondary transfer stations
- Development and management of sanitary landfill
- Manage Private, Community and NGO based waste management activities.
- Hospital waste management
- Environmental education activities
- Repairing and maintenance of vehicles and equipment used for waste collection
- Promote projects for Gas to Power and Compost from Waste

Each of the city corporations was divided into 5 Zones for zone wise collection and transportation of solid waste in Dhaka City. Figure 3 shows different waste collection zones of Dhaka city with existing landfill sites. Each of the zone has a zonal office consists of one Assistant Chief Waste Management Officer, two Conservancy Officers, one Conservancy Inspector for each ward, and two supporting staff. Apart from that waste cleaners and waste management drivers are distributed among the zonal offices and they work under the direct supervision of respective zonal office.

In addition to this, Section 50 of the Local Government (City Corporation) Act, 2009 (Amendment in 2011) reads that the corporation shall form a standing committee in its first meeting of the year or as early as possible, on some specific issues including waste management. Each of those committees shall consist of some members selected among the councilors of the corporation, where the Mayor shall be a member of each committee as ex-officio. Each committee shall function for a period of 2 years and 6 months, which shall be formed afresh just after the tenure.



Source: Developed by Author, 2015

Fig. 3: Waste Collection Zones of DNCC and DSCC with Existing Landfill Sites

Zone Wise Waste Storage Facilities of DSCC and DNCC

Islam, et al.(2012) found total number of waste storage facilities are 1,098 units, which include 341 units of dustbins, 346 units of containers, 402 Temporary Collection Points (TCP), 7 Trailer Containers and 2 units of 12 m³ containers as summarized in Table 3.

Table 3: Zone wise Dustbins and Waste Containers of DSCC & DNCC

Zone	Dustbin	Container	TCP
DSCC Zone-1 (Previous DCC Zone-5)	41	63	51
DSCC Zone-2 (Previous DCC Zone-4)	29	77	57
DSCC Zone-3 (Previous DCC Zone-3)	73	20	45
DSCC Zone-4 (Previous DCC Zone-2)	91	62	26
DSCC Zone-5 (Previous DCC Zone-1)	51	29	91
DNCC Zone-1 (Previous DCC Zone-10)	-	-	-
DNCC Zone-2 (Previous DCC Zone-8)	3	46	46
DNCC Zone-3 (Previous DCC Zone-9)	3	0	2
DNCC Zone-4 (Previous DCC Zone-7)	10	16	22
DNCC Zone-5 (Previous DCC Zone-6)	40	33	62
Total	341	346	402

Source: adapted from Islam, et al., 2012

Collection of municipal solid waste

Primary Collection and Road/Drain Cleaning

Though residents are responsible for bringing their waste to the waste collection points, NGOs/CBOs/private sector provide primary collection services to collect waste door-to-door and transport the waste to dustbins, containers, or sometimes to vacant lands, by rickshaw vans.

The private sector initiatives of NGOs and CBOs in primary collection services are now (2015) prevalent in wide areas of Dhaka city. Every morning cleaners sweep main roads, alleys footpath and put together the whole waste in a common place. Then bring it to the designated point/dustbin/container by hand trolley. Every day a team contains 10 to 12 cleaners send to the different location of ward for cleaning open drain/deep drain/surface drain and storm sewerage line (DNCC, 2014b). Figure 4 shows primary collection of solid waste using Rickshaw Vans.



Fig. 4: Field Survey at Banani DOHS, Dhaka in August, 2014 found Primary Collection of Solid Waste using Rickshaw Vans

Secondary Collection and Transportation

The city corporations are responsible for secondary waste collection to remove waste from its dustbins or containers, and transport the waste to final disposal sites. Field Survey found that all garbage of the DSCC is transported to Matuail landfill site while the DNCC uses Amin Bazar landfill site. Figure 5 shows different types of Garbage Trucks for secondary collection of municipal solid waste in Dhaka city.



Fig. 5: Field Survey at Zonal Office (Zone-4, Mirpur) of DNCC in December, 2014 found Different types of Garbage Trucks for Secondary Collection

For the secondary collection, the government procured 132 modern waste collection vehicles, including 40 compactors and 27 container carriers, to retrieve waste from the collection points and transport waste to the disposal site as stated in CCAP (2013). The Japanese government funded much of Dhaka's waste management fleet-the Environmental Grant Aid Program (EGAP) donated 100 vehicles, valued at USD 5 million (CCAP, 2013). The Japanese government also cancelled the debt incurred by Bangladesh for the purchase of 27 container carriers through the Debt Cancellation Fund (CCAP, 2013).

Manpower in the Collection and Transportation

In Dhaka city, about 7961 cleaners (Field Survey, 2015) are employed for street sweeping and collection of waste found in places other than dustbin, road side, open spaces, ditches etc. by hand trolley (Islam, 2003). For collection of accumulated waste in 180 containers within 75 sq. km. area, the DNCC has 115 demountable container carrier trucks, where the DSCC has 235 demountable container carrier trucks to collect accumulated waste in 270 containers from its 42 sq. km. area (Field Survey, 2015). Manpower allocation to collection and transportation in DNCC and DSCC is summarized in Table 4.

Table 4: Number of Cleaners and Drivers in DNCC and DSCC

Workers category	Number	
	DNCC	DSCC
Cleaner	3586	5300
Waste Management Drivers	108	183
Central Garage	1	1
Numbers of Waste carrying containers	180	270
Number of Waste Collection Trucks	115	235

Source: Information collected by author from WMD of DNCC and DSCC

Disposal of Waste

Dumping of Waste at Landfill Sites

Most of solid waste was disposed of at landfill sites without any intermediate treatment in Dhaka as reported by JICA in 2005. JICA study (2005) also found three landfill sites used by DCC, namely, Matuail, Beri Band (Embankment) and Uttara. Hai and Ali found six dumping sites (1) Kushi, (2) Chalkbari-Mirpur, (3) Gabtoli-Mirpur, (4) Lalbagh Shosan Ghat, (5) Mugdapara and (6) Jatrabari. DCC had already abandoned the sites after filling to their capacities (Hai and Ali, 2005). After partition of DCC, all garbage of DSCC is transported to Matuail landfill site while DNCC uses Amin Bazar landfill site for waste disposal (Field Survey, 2014).

In parallel with the technical cooperation activities, the Government of Japan supported other SWM activities in DCC including the improvement and expansion of Matuail landfill site and the construction of Amin Bazar landfill site under the Japan Debt Cancellation Fund (JDCF) as reported by JICA (2012). As stated about Matuail Landfill site by Yousuf and Rahman (2007), major sanitary landfill components introduced under the project were the leachate collection and gas venting systems, surface drainage improvement, systematic operation of waste disposal facilities by daily covering, slope reformation, working roads, weighbridge operation, and vehicle washing facilities. A semi-aerobic landfill system was adopted to reduce the polluting load on the environment and to speed up the stabilization of the disposed waste. A perforated pipe network for leachate collection and gas venting was installed for the proper collection of the leachate and the provision of an air supply system (Yousuf and Rahman, 2007). Same sorts of facilities were found in the Amin bazar landfill site during the field survey (2013). Though Matuail and Amin Bazar landfill sites have modern waste management facilities, those cannot be classified as sanitary landfill but controlled landfill. The dozer, chain dozer, scraper are being used to spread the waste regularly, hence waste pickers (TOKAI) salvage reusable materials from those dumping site. Figure 6(a, b) shows the worn-out situation of two permanent dumping stations in Dhaka.



(a) Matuail, Dhaka in April 2013



(b) Aminbazaar, Dhaka in April 2013

Source: Field Survey

Fig. 6 (a, b): Worn-out Situation of two permanent dumping stations in Dhaka City

Matuail landfill is well managed and operated as a whole despite the fact that the most of LMU (landfill management unit) staff are deputed or temporary employed. In Amin Bazar landfill site, while LMU has been organized, staffing is quite insufficient and landfill operation is carried out without a site manager and any specific operation plan (JICA, 2012). The management team comprises managers, reception and control staff, dumping platform instructors, heavy equipment operators, maintenance staff, and guards. The functions of the management unit are to develop the disposal plan, maintain the daily operation records, and manage the heavy equipment operation and daily cover application (Yousuf and Rahman, 2007). Both of these landfills actually operated round the clock with this manpower.

Organic Diversion

Chowdhury, et al. (2014) observed, only a small portion of Dhaka's organic waste is diverted before being transported to the city's landfills or deposited in open spaces. However, one small-scale, private composting company is currently (2014) collecting (for a fee) and processing approximately 100 metric tons of organic waste per day, and selling the compost to local farmers (Chowdhury, et al., 2014). Dhaka has preliminary plans to develop a larger Integrated Resource Recovery Center at one of the city's landfills to process waste into compost and to generate electricity using landfill gas as reported by Chowdhury, et al. (2014).

Recycling

According to Chowdhury, et al. (2014), Dhaka has historically relied on the informal recycling sector (e.g., waste pickers, of whom there are an estimated 12,000) for the recovery of non-organic materials. In an effort to recover more recyclable materials, the city launched a source separation pilot program in 2012 (Chowdhury, et al., 2014).

Private Solid Waste Management Using PPP

Private solid waste management in Dhaka City is approaching for Public Private Participation (PPP). Dhaka North City Corporation fully privatizes its conservancy works in Uttara, Gulshan, Banani, Baridhara, Mohakhali and Tejgaon areas. These areas cover the northern part of the city, and in zone 1 and 3, the private parties are handling this works very smoothly (DNCC, 2014b). The Urban Planning Department introduced this project for the first time. Then the project was handed over to the Waste Management Department of DNCC. The private parties do the street sweeping, drain cleaning, door-to-door waste collection, dustbin cleaning, waste transportation, and final disposal (DNCC, 2014b).

Composting Project in Dhaka Using PPP

A BMDF study (2012) found that in 2012 Waste Concern was operating a large scale compost plant in Dhaka, Bangladesh, using PPP. The organization submitted the waste composting CDM project for approval to Designated National Authority in March, 2006 and the project was approved in July 2006. Subsequently, a 15 year concession agreement was signed with Dhaka City Corporation (DCC) in 2007 (BMDF, 2012). This is the first concession agreement in solid waste recycling was launched in Bangladesh. Under this project, Waste Concern could collect up to 700 ton/day of organic waste (not mixed, only vegetable waste) incrementally starting from 100 ton/day (BMDF, 2012). Land for

composting is arranged by the Waste Concern along with collection of organic waste. No waste collection fee or tipping charge is provided to Waste Concern by the municipality. Moreover, if Waste Concern fails to collect waste, there is a penalty clause of Tk. 250/ton for non-collection of waste. All the vegetable markets are under the jurisdiction of Waste Concern for collection of waste (BMDF, 2012). However, for the first plant of 100 tons per day capacity, DCC has allowed Waste Concern to collect waste from six vegetable markets of Dhaka and a daily monitoring is done by the municipality on amount of waste collected by Waste Concern as stated in BMDF (2012).

Waste to Energy Project in Dhaka Using BOO

BMDF study (2012) revealed that LGD under MoLGRD&C had signed an agreement with SRL via Priore Berengario of Italy to install a 10 MW power plant in which primary fuel would be the waste generated in Dhaka City Corporation (DCC). The power plant would use 1,000 tons of waste per day generated in DCC. The project would be implemented using Build Own Operate (BOO) system (BMDF, 2012). Under that project, DCC would provide the company with land at the landfill site and purchase electricity from the plant at a price agreed by the parties. The selected company would have to sign two separate agreements with DCC and Power Division, one for waste management and another for buying electricity. The project was not yet implemented (BMDF, 2012).

External Support

A detailed study conducted by BMDF found that a project titled "Promotion of Source Separation of Waste in Dhaka and Chittagong" was being implemented by DoE in partnership with two Dhaka city corporations and Chittagong city Corporation (BMDF, 2012). This project was implemented as part of the National 3R strategy to promote segregation of waste at source and promote recycling. The project was financed by Climate Change Trust Fund of Government of Bangladesh to promote segregation of waste



Figure 7: Three types of bins provided for segregation of Waste at Source in Dhaka and Chittagong under the 3R pilot project (2012) adapted from BMDF (2012)

(BMDF, 2012). From April of 2012, the 3R pilot project was launched in Dhaka's Gulshan, Baridhara, Gonobhaban (Mohammadpur), Dhanmondi, and Minto Road (BMDF, 2012). As part of the project, three bins were provided for 50,000 households in Dhaka and Chittagong and an awareness raising campaign was also undertaken under this project as reported by BMDF (2012). The study also revealed that segregated waste would be composted and based on the results of the pilot project, it would be gradually extended all over the city. Figure 7 shows the picture of three types of bins provided under this project for segregation of waste at source.

External support agencies such as ADB, GIZ, World Bank and KfW are providing financial support to municipalities on solid waste management as part of urban

development project through LGED or LGD as reported by BMDF (2012). With financial and technical assistance from the Japan International Cooperation Agency (JICA), Dhaka designed a Solid Waste Master Plan in 2005 that set out to transform the municipal solid waste management system by 2015. The Plan sought to develop a participatory waste management program and to build government capacity in waste management. Moreover, JICA has also provided grants to improve the crude dumping site in Dhaka into a controlled landfill site and provided 100 reconditioned compactor trucks for waste collection CCAP (2013).

Waste Management Costs

Both the city corporations charge conservancy tax of 2% based on property's annual rental value. But there is always negative correlation between income and expenditure. According to the revised budget of 2013-14, DSCC spent 0.48% and 0.35% of total annual expenditure respectively for landfill operation, maintenance, development and for other conservancy activities. The budget reveals that DSCC paid 2.18 core BDT for the waste management of the city, including special conservancy activities (BDT 2.10 core) and landfill operation (BDT 0.08 core) as revenue expenditure. For landfill maintenance and development purpose, total BDT 2.83 core was expended from the development budget of 2013-14. The total revenue and development budget was revised as BDT 183.80 core and 419.75 core respectively by DSCC for the financial year 2013-14.

On the other hand, DNCC spent 0.41% and 3.86% of total annual expenditure respectively for landfill operation, maintenance, development and for other waste management activities during the fiscal year 2013-14. During the fiscal year of 2013-14, DNCC actually expended 16.12 core BDT for waste management, including community waste management (BDT 0.02 core), private waste management (BDT 15.00 core), special conservancy activities (BDT 0.40 core), and landfill operation (BDT 0.70 core) from the revenue budget. BDT 1.50 core was expended for solid waste workshop and BDT 2.20 core was expended to buy materials used for waste management activities under revenue budget. From development budget, BDT 0.10 core was expended to construct ward office for WMD, BDT 0.15 core was expended for waste management workshop, BDT 1.50 core was expended to construct dustbin/transfer station, BDT 1.50 core was expended for landfill maintenance and development purpose, and BDT 0.10 core was expended for drain cleaning and other development purposes. The total revised revenue and development budget was estimated as BDT 190.96 core and 352.75 core respectively by DNCC for 2013-14 fiscal year.

Awareness Raising Campaign

According to CCAP (2013), the community-based approach to waste collection engaged residents to expand and improve services and improve the working conditions of service providers, thereby reducing occupational health hazards. Increased rates of collection and disposal have improved water and air quality, and expansion of the solid waste management system created opportunities for employment (CCAP, 2013). The following awareness building activities are done by the city corporations as reported by DNCC (2015):

- Community meeting at ward level,
 - Conduct training program for community people with a view to developing the waste management system at their local community,
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- Arrange programs such as, rally and campaigning, distribution of leaflet and sticker, organize cultural program in different communities,
- Conduct environmental education program, and model school program to increase awareness about environment among the students at primary level,
- Publish quarterly newsletter.

Waste Collection Efficiency

The efficiency of EGAP vehicles received under the grant of Japanese government was found to be 4.05 ton/trip, while the efficiency of other DNCC/DSCC vehicles was found to be 2.75 ton/trip as estimated by the city corporations (DNCC, 2015). Figure 8 illustrates percentage of trips generated by different types of vehicles per day and Figure 9 presents percentages of waste carried by different types of vehicles per day to Matuail and Amin Bazar landfills.

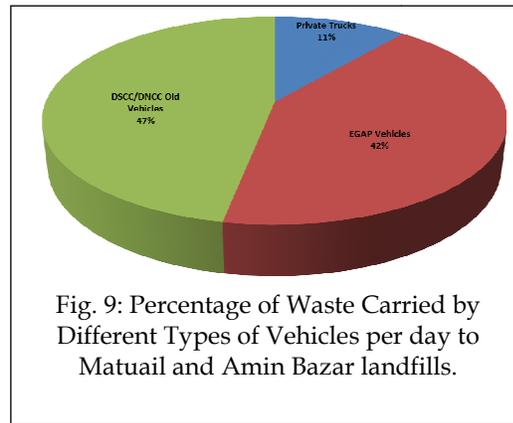
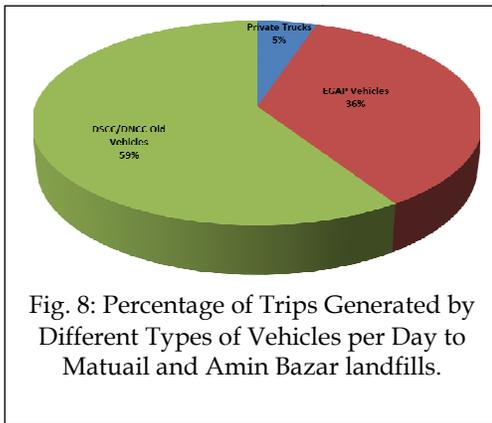


Figure 8 reveals that 59% of trips are generated by city corporations' old waste collection vehicles and 36% are by EGAP vehicles and 5% are by private trucks. Figure 9 exhibits that city corporations' old vehicles carry 47% of total waste collected per day, where private trucks carry 11% and EGAP vehicles carry 42% of daily collected waste.

Conclusion

Municipal Solid Waste Management is a complex system considering its inclusion of various stakeholders from waste generation to management. Apart from this, a number of technical issues are correlated with the waste management system. The increasing amount of waste raises the demand of land for land filling and also increases the emission of GHG. The study reveals that both of DNCC and DSCC have taken the waste management issue seriously and the establishment of WMD is an indication of that seriousness. But in fact, some problems are hampering proper waste management by the city corporations such as, shortage of technical manpower and insufficient infrastructure facilities both at headquarters and zonal offices of WMD, insufficient regulations about waste management, and lack of awareness among the city dwellers about their role in waste management. It goes without saying that both the city corporations have to pull

their socks up in all sectors, i. e., managerial, technical, and financial sectors to tackle this menace properly and safely.

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