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Generation and Assessing the Composition of Commercial Solid Waste in Commercial City of Bangladesh

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ABSTRACT

The study was conducted in Jamalkhan Ward, Chittagong, Bangladesh to determine the generation rates, physical composition and characterization of commercial solid waste (CSW) and to identify the current situation of commercial solid waste management. A structured questionnaire was processed and waste collected from different waste generating sources were segregated and weighed. Commercial solid waste generation rate was found 0.44kg/person/day and an average commercial unit generated 3.61 kg of waste per day. In the generation of CSW, vegetable/food waste was highest (35%) followed by 14% of packaging material and 13% of plastic/polythene/rubber and lowest (2%) found as can/metal/tin. By weight, 57% of the waste was compostable in nature. The generation of CSW was found positively correlated with staff size (r_{xy} = 0.8245) at 1% significant level, which means commercial unit with more staff generate larger quantity of solid waste per day. It was also found a positive correlation between the establishment cost (r_{xy}= 0.9945) and the generation of solid waste at 1% significant level which reveals commercial unit that required large establishment cost have the tendency to generate larger quantity of solid waste each day. Municipal authorities are usually the responsible agencies for solid waste collection and disposal, but the magnitude of the problem is well beyond the ability of any municipal government to tackle. It is necessary to take initiatives by both public and private sectors for effective management of waste. For systematic collection and disposal of the commercial waste, it is essential to develop ward-based participatory solid waste management programs.

Key words: Characteristics, Commercial waste, Compostable, Disposal, Generation, Management

1. INTRODUCTION

Solid waste: It means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities.

Solid waste production and their disposal has become a matter of great concern in developing countries. This is mainly due to population growth and unplanned urbanization. Due to rapid population growth and uncontrolled urban expansion urban environment is degrading severely. For most of the cities in developing countries mass production and disposal of solid waste is an obvious cause for the environmental degradation (Asraf, 1994). Due to rapid urbanization two-thirds of the world's people living in cities by 2025 and urban populations in developing countries grow by more than 150,000 people every day (UNDESA, 2005). The ever- increasing consumption of resources has resulted in enormous amounts of solid waste from industrial to domestic activities which can pose major threats to human health (Frosch, 1996). Ongoing advancements in science and technology have also contributed significantly to the increased volume and toxicity of waste generation (Sangodoyin and Ipadeola, 2000). Population density, community size, consumption habits of the population, monthly wages per capita, number of persons per dwelling, percentage of urban population, age, sex, ethnicity of the population, size of housing, geographical characteristics, land use, productive activities and communitarians are some common factors that have the influence on waste generation (Matsuto and Ham, 1990; McBean and Forting, 1993). Population is the over- riding factor influencing unit waste generation rate (Hocket et al., 1995). For proper solid waste management a reliable estimation of the quantity of solid waste generated in a city is very important. Most of the reported values of solid waste generation have been derived empirically with assumptions regarding population, number of vehicles available for transportation of wastes (Anon, 2001). Human activities create waste and the intense human activities concentrate, such as in urban centers, appropriate and safe solid waste management. Typically one to two thirds of the solid waste generated is not collected by many municipalities (World Resources Institute, 1996). Many of these waste materials can be reused (Kumar and Bhowmick, 1998) and thus may eventually become valuable resources if they are removed from the waste stream (World Bank, 1999). In fact, waste of most developed countries is regarded as resources.

The issue of poor solid waste management (SWM) has become a challenge for governments of developing countries in Asia and Africa (Calo` and Parise, 2009; Halla and Majani, 2003; Mwangi, 2000; Ogu, 2000; Zia and Devadas, 2008). Hence, this has huge consequences in terms of collection, disposal and the elimination of waste (Thonart et al. 2005; Moghadam et

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SOLID WASTE MANAGEMENT SYSTEM IN BANGLADESH

Chittagong city is facing great difficulties because of high rates of urbanization in Bangladesh due to rural exodus. The development and establishment of the Chittagong city corporation are increasing day by day with a wider variation of people living and working here. Commercial solid waste generation has also increased proportionately with the growth of urban population. The existing solid waste management system in Bangladesh is not well organized and hence not serving the proper solution of the problem. Increased amount of commercial solid wastes generated by a large population of Chittagong city are dumped indiscriminately to nearby places i.e. open dumping sites. The densely populated city corporation area is now going to be a potential threat of environmental pollution as the generated solid waste are not disposed in a safe method. In order to deal with the prevailing situation in a planned way, intensive study is required to analyze the urban waste management scenario of Bangladesh.

Waste management: It is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics.

al. 2009). In almost all developing countries, city solid waste constitutes a hazard, be it from the ecological point of view or the public health point of view. Almost everywhere, there is a distinct lack of policy on efficient waste collection and a total absence of its treatment (Culot et al. 1999). Many experts from various cities in developing countries have expressed serious concern about improper waste treatment and disposal in these countries (Berkun et al. 2005; Pokhrel and Viraraghavan, 2005; Barton et al. 2008; Chung and Lo, 2008; Imam et al. 2008; Sharholy et al. 2008). In most developing countries, solid waste management is undertaken by the local authorities. These services include waste collection (either from households or district collection points) to final disposal. However, the low financial base and human resource capacity of these local authorities mean that in most cases they are only able to provide a limited service (Barton et al. 2008). Inadequate management of solid waste in most cities of developing countries leads to problems that impair human and animal health and ultimately result in economic, environmental and biological losses (Wilson et al. 2006; Kapepula et al. 2007; Sharholy et al. 2008).

Bangladesh is a densely populated country is undergoing rapid urbanization (Salequzzaman, 2000). In Bangladesh 16,380 tons of wastes are produced per day (Anon, 2004). Chittagong is the second largest city of Bangladesh with a substantial, self- sustaining economic base (GoB, 2003). The solid wastes generation in urban areas of Chittagong city is increasing proportionately with the growth of its population, which is posing a serious threat to the solid waste management and disposal system (Sujauddin et al., 2008). The average generation of solid waste in the urban areas of Chittagong city is 1550 tons per day (Sinha, 2006).

Solid waste management (SWM) is a multidimensional challenge faced by urban authorities, especially in developing countries like Bangladesh (Sujauddin et al., 2008). Solid waste (SW) is irreparably degrading the urban environment and placing a serious threat to the natural resources (Kumar and Bhowmick, 1998). Developing countries generate less solid waste per capita because of their lower purchasing power and the consequent lesser consumption (Cairncross and Feachem, 1993). But the total solid waste contribution from such a big population is huge enough to create environmental problem (Salequzzaman, 2001). With the conventional system of collection, transportation and crude dumping of solid waste, municipal areas of Bangladesh are generally faced with rapid deterioration of environmental and sanitation condition. Municipal services in most big cities are already over burdened and simply cannot meet the growing demand of municipal services, resulting in unhygienic and filthy living condition in the neighborhoods (Enayetullah et al. 2005).

Municipal authorities are responsible for SWM in Bangladesh. SWM in municipalities operates under the conservancy wings executed by Chief Conservancy Officer (CCO) under the direct supervision of the Mayor of the city corporations. The most important task of these authorities is to manage the waste properly to keep the city clean and healthy. However, municipal services in most cities and towns are already over-burdened and simply cannot cope with the growing demand owing to insufficient manpower and materials, resulting in unhygienic and filthy living condition in the neighborhood (Enayetullah et al., 2005; Hasan and Chowdhury, 2005).

The solid waste generation of the urban area in Chittagong city is increasing proportionately with the growth of population, which is posing serious threat to the management and disposal of solid waste (Salam et al., 2012). Ethically, proper waste management is most important task of the city corporation for keeping the city clean and healthy. But municipal solid waste disposal by the city corporation is being an unmanageable burden to the city managers. The major problem of waste management, however, is the people's attitudes and behavior. Beside this, physical planning issues, government system and policies, and administrative and managerial procedures are considered as some of the major waste management problem in Chittagong city (Hasan, 1998).

In order to deal with the prevailing situation in a planned way, proper study is required to analyze the commercial waste management scenario of Bangladesh (Enayetullah et al., 2005). Recent information on SW at national (Ashraf, 1994; Bhide, 1990; DCC and JICA, 2004; Enayetullah et al., 2005; Hasan, 1998; Hasan and Chowdhury, 2005; IFRD and BCSIR, 1998; Rahman et al., 1999; Rahman, 2000; Rahman et al., 2006; Salequzzaman et al., 1998; Sinha and Enayetullah, 2000) considering municipal solid waste management. No study yet undertaken to assess the commercial waste generation scenario of Bangladesh. It is necessary to quantify the amount of waste generated as well as the current solid waste management practice so as to identify the problem and future prospects. This study attempts to make a move in this direction. The objectives of the study were, therefore, to make a move in the systematic study of commercial solid waste management (CSWM), leading to quantification of the amount of waste generated from the residential area, determination of its composition, and to quantify the different composition characteristics of CSW.

Compostable wastes: These are biodegradable wastes such as food waste, garden waste, animal waste and human waste. They undergo biological degradation under controlled conditions and can be turned into compost (soil conditioner or organic fertilizer) by mixing them with soil, water, air and biological additives/activators.

2. MATERIALS AND METHODS

The study was carried out at Jamalkhan ward of Chittagong City Corporation, Bangladesh. There are 41 wards (administrative areas) in CCC (Sujauddin et al., 2008). The study area is under ward number 21 and it was selected purposely for the research. The methodology followed for the performance of research tasks involved a review literature; definition of the problem; clarification of study objects; design of the survey plan; implementation of the person interview survey; establishment of the measurement of commercial daily solid waste generation and waste classification by type; processing of the survey data; analysis of the data and evaluation of findings and finally, preparation of the final research report. Data from different sources were utilized in the research study; questionnaires for the municipal solid waste management authority i.e., Chittagong city corporation; questionnaires for commercial unit and collected waste from different commercial sources. At the outset of the major field work, a reconnaissance survey was conducted during the early stage of research in June, 2007 to identify the socio economic status and solid waste generation scenario of the study area, especially the sources and sub-sources from where the solid waste is generated, to observe the physical condition of the study area and to get information regarding quantity and quality of commercial solid waste. A structured questionnaire was designed, pre-tested, and modified to collect commercial solid waste related data. Based on the reconnaissance survey carried out at Jamal khan ward, all the commercial units were categorized into 10 major types. These 10 major types of commercial unit were selected according to the frequency of specific type at Jamalkhan ward. Name of the major commercial categories mentioned below: a) Doctor's chamber and Pharmacy; b) Furniture gallery; c) Grocer's shop; d) Sanitary equipment shop; e) Vegetable market; f) Fish/meat market; g) Flower's shop; h) Refreshing corner; i) Stationary shop; j) Hotels/Restaurants. Ten commercial units from each category were randomly selected and thus a total of 100 commercial units were studied out of

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Table 1 Commercial Solid waste generated by commercial unit per day

Name of the commercial category	Number of CU* studied	CWGR** (Kg/CU/day)
Doctor's chamber and pharmacy	10	1.3
Furniture gallery	10	4.45
Grocer's shop	10	2.5
Sanitary equipment shop	10	1.59
Vegetable market	10	3.4
Fish/meat market	10	1.88
Flower's shop	10	4.74
Refreshing corner	10	2.06
Stationary shop	10	1.07
Hotels/Restaurants	10	13.1
Total	100	3.61 (Avg.)

*CU= Commercial Unit; **CWGR= Commercial Waste Generation Rate

Table 2 Commercial Solid waste generation per person per day

Name of the commercial category	Number of staff studied	CWGR** (Kg/person /day)
Doctor's chamber and pharmacy	29	0.25
Furniture gallery	99	0.21
Grocer's shop	45	0.28
Sanitary equipment shop	46	0.17
Vegetable market	20	0.86
Fish/meat market	22	0.43
Flower's shop	28	0.86
Refreshing corner	25	0.41
Stationary shop	23	0.24
Hotels/Restaurants	94	0.70
Total	580	0.44 (Avg.)

*CWGR= Waste Generation Rate

670 commercial units in the selected residential area under Jamalkhan ward. The commercial unit sample was 15 % of the total commercial unit of the study area. During the questionnaire survey, polythene bags (similar size and with particular coding of the respondent) were supplied to each commercial unit to place their commercial wastes. Collected wastes from each commercial unit within the poly bag were weighed and recorded. Then the wastes within each bag were segregated and each segregated item was weighed separately and recorded. The same job was conducted each day for each of the 100 commercial units. During segregation, collected wastes from each bag were spread on clean plastic sheets and the wastes sorted by hand, following the methodology of Salam et al (2012), Sujauddin et al (2008) and Enayetullah et al. (2005):

_ Paper = paper/book/printed materials
_ Pack = packaging materials
_ Can = can/jar/tin/metals
_ Plastic = plastic/polythene/rubber
_ Textile = textile/rags/jute
_ Glass = glass/ceramic
_ Vegetable = vegetable/food waste
_ Rocks = rocks/dirt/miscellaneous
_ Wood = wood/grass/leaves

3. RESULTS AND DISCUSSION

3.1. Commercial solid waste (CSW) generation

The analysis of the 100 sample observations in the study area indicates that an average commercial unit generated 3.61 kg of waste per day (Table 1). It also reveals that the rate of waste generation varies in different category of commercial unit studied. For this reason the waste generation rate by an average commercial unit was minimum (1.07 Kg/day) by the stationary shop and maximum (13.12 Kg/day) by the hotels/restaurants. The commercial waste generation rate per person in Jamalkhan is 0.44 Kg/day. The rate of waste generation per person varies in different category of commercial unit studied (Table 2). The study area comprises with 673 commercial units and almost 5040 staffs were engaged in those commercial units. This study interprets that almost 1911 kg of commercial solid waste was generated per day in the study area.

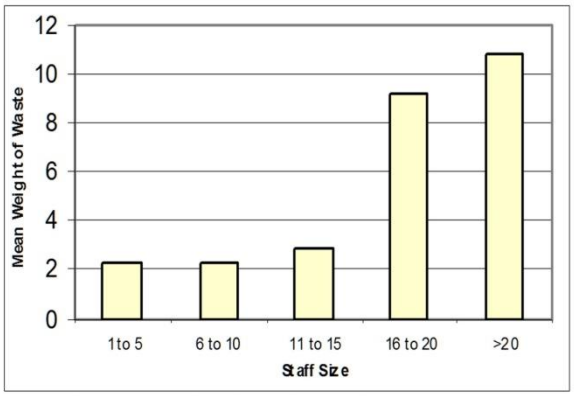

Figure 1
Generation of CSW based on staff size of commercial unit

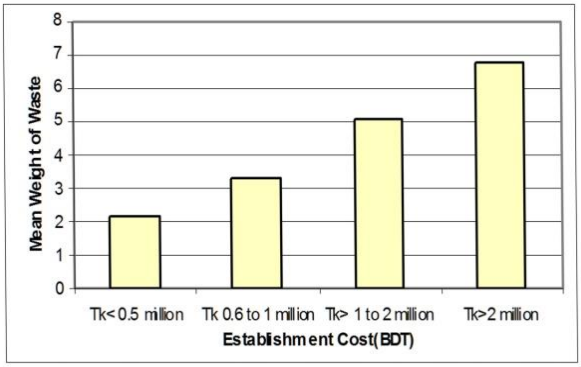

Figure 2
Generation of CSW based on establishment cost of commercial unit

3.2. Physical composition of CSW generated by different commercial category

The physical composition of solid waste varies with different purposes of commercial categories (Table 3). Variation was found among nine items between all the fifteen different commercial categories. Paper/ printed materials were found the highest (15%) in Grocer's shop followed by 11% for both Doctor's chamber and Stationary shop. Packaging material was found highest 31% in Stationary shop followed by 16% in Refreshing corner. Plastic /polythene was found maximum (36%) in stationary shop. Vegetable/food waste found maximum (77%) in hotels/restaurants followed by 74% in flower's shop and 72% in vegetable market. Textile was found maximum (37%) in doctor's chamber. Glass/ceramic was recorded highest (43%) in sanitary equipment. Grass/wood/leaves were recorded highest (63%) in furniture gallery. Table 3 also reveals that 57% of the waste was compostable in nature by weight.

3.3. Relationship between the Quantity of Solid Waste and Socio-Economic Factors

Correlation analysis was employed to identify the degree of association between two factors since the socio-economic factors affect commercial unit's daily quantity of solid waste. The generation of CSW was found positively correlated with staff size (r_{xy} = 0.8245) at 1% significant level, which means commercial unit with more staff generate larger quantity of solid waste per day (Figure 1). It was also found a positive correlation between the establishment cost (r_{xy} = 0.9945) and the generation of solid waste at 1% significant level which reveals commercial unit that required large establishment cost have the tendency to generate larger quantity of solid waste each day (Figure 2).

3.4. Compostable and non-compostable waste

The quantity of Compostable and non-compostable waste of CSW generated in Jamalkhan ward is shown in Table 4. From the study we were found the average compostable waste of CSW generation per commercial unit was maximum (9.3 kg/day) for hotels/restaurants and minimum (.68 kg/day) for stationary shop and average non- compostable waste of CSW generation per institution maximum (4.4 kg/day) for hotels/restaurants and minimum (.32 Kg/day) for fish/meat market. Table 5 also reveals that the compostable waste of CSW generation by a person in the study area maximum (1.55 Kg/day) for flower's shop and minimum (0.165Kg/day) for sanitary equipment and average non-compostable waste of CSW generation by a person maximum (0.42 kg/day) for hotels/restaurants and minimum (0.05 Kg/day) for grocer's shop.

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Table 3 Physical composition of CSW generated by different commercial category

Name of Commercial category	Waste category (%)								
	Non-compostable						Compostable		
	Paper	Pack	Plastic	Can	Glass	Rock	Vegetable	Textile	Wood
Doctor's chamber	11	8	19	9	0	3	13	37	0
Furniture gallery	9	0	0	13	0	6	6	3	63
Grocer's shop	15	11	9	0	0	7	53	5	0
Sanitary equipment	2	15	6	2	43	11	4	0	15
Vegetable market	0	0	14	0	0	7	72	5	2
Fish/meat market	0	0	17	0	0	10	69	2	2
Flower's shop	2	4	8	0	0	7	74	5	0
Refreshing corner	9	16	13	5	3	3	51	0	0
Stationary shop	11	31	36	0	0	12	6	4	0
Hotels/Restaurants	6	4	1	0	6	4	77	2	0
Generation of waste per day by all commercial category	9	14	13	2	7	8	35	6	6

Table 4 Quantity of compostable and non-compostable waste generated by commercial categories

Name of Commercial category	Compostable (Kg)		Non-compostable (Kg)	
	hh/day(Kg/day)	Person/day(Kg/day)	hh/day(Kg/day)	Person/day(Kg/day)
Doctor's chamber	0.938	0.323	0.364	0.125
Furniture gallery	3.948	0.4	1. 5	0.15
Grocer's shop	2.235	0.5	0.225	0.05
Sanitary equipment	0.76	0.165	0.81	0.176
Vegetable market	3.407	1.7	0.48	0.24
Fish/meat market	1.564	0.71	0.32	0.145
Flower's shop	4.355	1.555	0.38	0.136
Refreshing corner	1.596	0.64	0.384	0.154
Stationary shop	0.684	0.297	0.4	0.17
Hotels/Restaurants	9. 3	0.88	4.4	0.42

4. CONCLUSION

In order to deal with the prevailing situation in a planned way, proper study is required to analyze the urban waste management scenario of Bangladesh. One of the first critical steps in the process of developing a reliable waste management plan requires a comprehensive understanding of the quantities and characteristics of the waste that needs to be managed. It is necessary to quantify the amount of waste generated as well as the current solid waste management practice so as to identify the problem and future prospects. This study attempts to make a move in this direction. This study also attempts either there is any feasibility to establish different sorts of plant by means of which wastes can be reused based on the waste generation. CSWM refers to all activities pertaining to the control, collection, transportation, processing and disposal of waste in accordance with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. Its scope includes all participatory administrative, financial, legal, planning and engineering functions (Salequzzaman *et al*., 2001). Developing integrated solutions for waste management problems requires public involvement. To economically and efficiently operate a waste management program requires significant cooperation from generators. When waste generation is unavoidable, the materials can be viewed as a resource. The objectives of the study were largely met, giving what may be considered as baseline data on the solid waste situation in the municipal areas of Bangladesh. This should lead to a better understanding of the solid waste management problems in Bangladesh. A waste stream assessment is not a one-time activity. As management programs are implemented, periodic waste stream assessments will be required to identify successful protocols as well as areas needing improvements. Furthermore, seasonal or temporal variations make it imperative that the waste stream assessment be carried out in widely contrasting seasons (Sha'Ato *et al*., 2007). Thus, it is recommended that this study be repeated during all of the seasons, to give a more complete picture of the municipal solid waste situation.

Recyclable wastes: These refer to any waste material retrieved from the waste stream and free from contamination that can still be converted into suitable beneficial use. These may be transformed into new products in such a manner that the original products may lose their identity.

5. RECOMMENDATIONS

Considering the situation and field observation, the following recommendations for CSWM are as follows:

- During the study, it was found that systematic collection of the commercial waste totally absent in the study area. It should empower the private sector to pick up waste from those sources can usually be self-financing.
- For systematic collection of the solid waste, it should arrange ward-based participatory solid waste management where community participation, volunteerism and empowerment are ensued.
- Recycling and reuse should be given priority to reduce waste generation volume and lessen treatment and disposal cost. Planned recycling in the waste generation point, and dustbins should be introduced.
- Source separation of waste should be encouraged by providing specific type of dustbin or storage for disposing specific type of waste category.
- The most important principles underlying effective programs for the management of MSW include the awareness, assignment of legal responsibility, developing the rules and regulations and also need of a national waste management policy and national waste disposal and management guideline for Bangladesh concerning to the MSW.

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