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Generation of Municipal Solid Waste in Commercial City of Bangladesh

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Abstract

The study was conducted during January to December 2009 to determine the generation of municipal solid waste (MSW) in Chittagong City Corporation of Bangladesh. A structured questionnaire was processed and waste collected from different waste generating sources were segregated and weighed. Residential waste generation rate varied in different socio economic groups and was found minimum (0.5 Kg/day) in Low Socio-economic Group and maximum (3.54 Kg/day) in High Socio-economic Group and an average residential unit generated 1.72 kg of waste per day. Commercial waste generation rate by a person was found 0.38 Kg/day. Waste generation rate by an average institution was recorded minimum (5.4 Kg/day) by the religious institution and maximum (17.05 Kg/day) by the government institute and an average institution generated 10.2 kg of waste per day. The average waste generation rate by a large-scale industry was found 435 kg/day and small-scale industry 77 kg/day and average industrial waste generation was 256 kg/day. The average medical waste generation was found 33 kg/day. Medical waste generation rate per patient was 0.595 kg/day. 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.

Key words: Solid Waste Disposal, Residential Waste, Industrial Waste, Institutional Waste, Waste Management

1 Introduction

Municipal solid waste (MSW) disposal is a global concern [1], most especially in developing countries across the world, as poverty, population growth and high urbanization rates combine with ineffectual and under-funded governments to prevent the efficient management of wastes [2,3]. MSW management systems are becoming more complex in many countries with movement from landfill-base systems to resource-recovery-based solutions [4,5]. Cities in developing countries are confronting a twin dilemma namely rapid growth of urban population resulting in increased demand of waste management services and poorly developed traditional public sector to the growing demand for such services [6]. The issue of poor solid waste management (SWM) has become a challenge for governments of developing countries in Asia and Africa [7-11]. Hence, this has huge consequences in terms of collection, disposal and the elimination of waste [12,13]. Improper SWM is considered to be one of the most burning and serious environmental problems in developing countries like Bangladesh [14]. The progress of modern civilization and the associated increase in population worldwide has contributed significantly to the increase in the quantity and variety of waste generated. SWM is a multidimensional challenge faced by urban authorities, especially in developing countries like Bangladesh [15]. It is an integral part of the urban environment and planning of the urban infrastructure to ensure a safe and healthy human environment while considering the promotion of sustainable economic growth. The management of MSW is a highly neglected area of the overall environmental management in most developing countries. SWM systems in developing countries must deal with many difficulties, including low technical experience and low financial resources which often cover only collection and transfer costs, leaving no resources for safe final disposal, these factors are further exacerbated by inadequate financial resources, and inadequate management and technical skills within municipalities and government authorities. Developing nations are now seriously concerned with the consequences of improper handling of MSW [16]. MSW management in most low and middle income countries draws on a significant proportion of the municipal budget, yet current practices pose a serious threat to the environment and to public health and well being. This may result in such consequences as pollution, reduction of aesthetic values and economic losses due to failures in recycling and composting valuable components of MSW. Furthermore, poor management of solid waste (SW) may result in serious urban, sanitary and environmental problems such as an unpleasant odor and the risk of explosion in landfill areas, as well as groundwater contamination because of leachate percolation [17].

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Municipal waste (MW) includes domestic as well as commercial and industrial refuge, street sweepings and construction and debris [18]. In the developed world, for example the USA, industrial refuge is not a part of municipal refuge. In the developing countries, MW may include industrial waste but domestic wastes generally account for between 60% and 80% of total MSW. Currently, a gigantic volume of MSW is generated every day in the big cities of Bangladesh and consequently, a blocking created between demand and supply for MSW management in most of the urban bodies.

In high income countries, though MSW can be around 3000 grams per capita daily, in low-income countries it is sometimes around only 300 grams per person daily. In some south Asian cities, for example, in Karachi, daily average per capita SW amounts to around 700 grams and in Calcutta it is 500 grams. In Dhaka and Chittagong cities it is 350 grams per person per day [18]. The major constituents of SW originating in the cities of the developed countries are non-biodegradable packaging materials and containers. In contrast, vegetables and putrescibles make up between 40-85% of total MWs in low-income countries; whereas, for mid and high-income countries is 20-65% and 20-50%, respectively. The major constituents of waste in Dhaka and Chittagong cities are organic and compostable materials [18].

1.1 MSW scenario in different Asian countries

The quantity of SW generation is mostly associated with the economic status of a society. Accordingly, Table 1 shows GDP together with waste generation rates for some of the largest Asian countries. It can readily be seen that waste generation rates are lower for developing economics that have lower GDP.

1.2 MSW: Bangladesh perspective

Total number of urban areas in Bangladesh is 514, which includes 6 City Corporations, 298 Pouroshavas (Municipalities) and 210 other urban centers. Table 2 depicts total waste generated in the urban areas of Bangladesh per day is 13,332.89 tons. Based on the total estimated urban population of the year 2005, per capita waste generation rate is computed as 0.41 kg/capita/day (Table 2).

Table 1: Current urban MSW generations in some Asian countries [33]

Country	GDP per capita estimated for 2007 (USD)	Waste generation (Kg/ capita/day)
Hong Kong	37,385	2.25
Japan	33,010	1.1
Singapore	31,165	1.1
Taiwan	31,040	0.667
South Korea	23,331	1.0
Thailand	12,702	0.5-0.8
Malaysia	9426	1.1
China	8854	0.8
Philippines	5409	0.3-0.7
Indonesia	5096	0.8-1
Srilanka	5047	0.2-0.9
India	3794	0.3-0.6
Vietnam	3502	0.55
Lao PDR	2260	0.7
Nepal	1760	0.2-0.5

In order to deal with the prevailing situation in a planned way, proper study is required to analyze the MWM scenario of Bangladesh [19]. Recent information on MSW both at national [14, 18-30; and international level [16, 31, 32] considering municipal solid waste management. A number of studies have been conducted in Bangladesh and few studies have also been conducted in Chittagong on the issue of waste management. But an integrated study enveloping manifold aspects of waste management like waste generation, reasons behind improper waste management have got little focus in previous studies. This research gap has created proclivity in present researchers to conduct a research on the issue.

2 Methodology

Data from different sources were utilized in the research study; questionnaires for residential unit, commercial unit, institutional unit, field observation about municipal service and collected waste from those sources.

At the outset of the major field work, a reconnaissance survey was conducted during the early stage of research in January, 2009 to identify the socio economic status and SW generation scenario of the study area, especially the sources and sub-sources from where the SW is generated, to observe the physical condition of the study area and to get information regarding quantity and quality of SW.

The community based organization (CBO) usually work under the supervision of the ward councilor. So, all data concerning CBO are also collected from local ward councilor office. The data concerning CCC, such as estimated generated waste for study area, equipments, number of cleaners, and number of containers in the study area were collected from conservancy inspector of CCC for respective wards. For assessment of the financial and environmental aspects of recycling wastes, the data about buying and selling of recycling shop was collected for a period of two months from different category of recycling units in each of selected ward area.

Six structured questionnaires were designed, pre tested and modified to collect residential, commercial, municipal, medical, institutional, and municipal service SW related data and daily SW traits.

Table 2: Estimated quantities of SWG in Bangladesh [19]

City /Town	Total population	Waste Generation Rate (kg/cap/day)	Average Total Waste Generation (TWG) (ton/day)
Dhaka	6,728,404	0.56	4,634.52
Chittagong	2,622,098	0.48	1,548.09
Rajshahi	468,378	0.30	172.83
Khulna	967,365	0.27	321.26
Barisal	437,009	0.25	134.38
Sylhet	386,896	0.30	142.76
Pourashavas	15,214,306	0.25	4,678.40
Other Urban Centers	9,217612	0.15	1,700.65
Total	36,042,067	0.41 (avg)	13,332.89

2.1 Determination of municipal SW generation

Determining the MSW generation, different procedure and method are followed for assessing residential, commercial, municipal service, institutional and industrial daily SW generation and waste classification by type separately.

2.1.1 Sampling for determining residential SW generation

The study was carried out during the month of June, 2009 and November, 2009 to know the quantitative and qualitative aspect of residential SW generation at city

corporation area. Based on the reconnaissance survey, five residential area; Khulsi, Sugandha, Chandgong, Chakbazar, Patharghata were selected for determining residential SW generation. According to Clean Dhaka Master plan (Implemented by JICA & Dhaka City Corporation-DCC) the whole study area was classified into four different socioeconomic groups on the basis of the household's monthly income: High socioeconomic group (HSG) (monthly income above BDT 20,000), Middle socioeconomic group (MSG) (monthly income between BDT 10,000 and BDT 20,000), Lower middle socioeconomic group (LMSG) (monthly income between BDT 5000 and BDT 10,000), and Low socioeconomic group (LSG) (monthly income < BDT 5000). Twenty-five households from each group were randomly selected and thus a total of 100 households were studied.

2.1.2 Determining commercial SW generation

To know the quantitative and qualitative aspect of commercial SW generation along with the seasonal variation at City Corporation area a detailed study was conducted during June 2009 and November 2009. Based on the reconnaissance survey, all the commercial units were categorized into 5 major types. Major commercial categories are grocer's shop & stationary shop, vegetable & fish/meat market, and refreshing corner/ sweetmeat shop, hotels/restaurants and others shop. Based on the reconnaissance survey, five commercial area; Reazuddin Bazar, Agrabad, Chakbazar, GEC circle, and Caktai were selected for determining commercial SW generation. Twenty-five commercial units from each category were randomly selected and thus a total of 125 commercial units were studied.

2.1.3 Determining institutional SW generation

Based on the reconnaissance survey carried out at different wards, all the institutional units were categorized into 4 major types. The major institutional categories are; a) educational institution; b) government institution; c) private institution; and d) religious institution. The study was conducted during the month of July 2009 and November 2009 to know the quantitative and qualitative aspect of institutional SW generation at city corporation area. Based on the reconnaissance survey, five area; Kotowaly, Agrabad, Jamalkhan, Panshlise, and Sholoshahar were selected for determining institutional SW generation. Fifteen institutional units from each category were randomly selected and thus a total of 75 institutional units were studied.

2.1.4 Determining industrial SW generation

To know the quantitative and qualitative aspect of industrial SW generation along with the seasonal variation at City Corporation area a detailed study was conducted during June, 2009 and December, 2009. Based on the reconnaissance survey, two industrial areas namely; Chittagong export processing zone (CEPZ), and Nasirabad industrial area were selected for determining industrial SW generation. Twenty industrial units were randomly selected and studied.

2.1.5 Determining medical waste generation

The study was carried out in Chittagong medical college hospital (CMCH) and ten private clinics. The CMCH comprises 34 wards. Twelve wards were selected randomly to obtain data on the quantitative qualitative aspects of medical waste. The waste materials of a particular ward were collected and brought to the waste container of the CMCH on the specified day. The waste materials of a particular ward was weighed and recorded. A similar procedure was followed for ten private clinics.

2.1.6 Determining municipal service SW generation

Based on the reconnaissance survey at different ward, 10 major roads and drains were identified. Chittagong City Corporation has the main responsibility for those roads and drains cleaning. Waste sample collected to determine the quantitative and qualitative aspect of municipal service SW generation at city corporation area.

2.2 Collection of the primary data

Two different types of data were studied in residential, commercial, institutional, industrial, medical, municipal service level on SW generation and daily SW traits. During the questionnaire survey, three polythene bags were supplied to each residential and commercial unit to place their residential and commercial wastes of different three days. On the other hand institutional waste, medical waste and industrial waste of different three days were collected from institutions and industrial's own waste storage device and municipal service waste of different three days were collected from the wheel barrows of the waste collection team. To determine the seasonal variation waste collected twice within a year, once at rainy or wet season (June and July, 2009) and another at winter or dry season (November and December 2009).

Collected wastes were weighted and recorded. Then the wastes within each bag were segregated, weighted separately and recorded. The same job was done for each three days for all the collected sample waste. During segregation, all collected wastes from each bag were spread on clean plastic sheets and the wastes sorted by hand, following the methodology of [19]; i.e; 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/leave, hazardous= medical hazardous waste.

3 Results and Discussion

3.1 Waste generation

The study reveals that the waste generation per unit per day of major MSW sources in rainy was widely increased than that in winter season (Table 3). For this reason the waste generation per capita per day of major MSW sources in rainy was increased than that in winter season (Table 4). The finding of the present study is in agreement of Clean Dhaka Master Plan, [24]; where it observes that waste generation per unit per day and waste generation per capita per day are higher in the rainy season than that in winter season.

The study reveals that the rate of residential waste generation varied in different socio economic groups and was found minimum (0.5 Kg/day) by the LSG and maximum (3.54 Kg/day) by the HSG and an average residential unit generated 1.72 kg of waste per day (Table 3). The average residential waste generation rate per person was 0.323 Kg/day (Table 4). The findings are in agreement with [15] who find the waste generation rate in Rahman Nagar Residential Area is 0.25 kg/person/day.

Table 3: SW generation per unit per day of major MSW sources

Major Sources	Rate (Kg/unit/day)		
	Dry Season	Wet Season	Average
A) Residential Solid Waste (RSW)			
a) Higher Socio- economic Group (HSG)	3.12	3.96	3.54
b) Upper-Middle Socio economic Group (UMSG)	1.54	2.49	2.00
c) Middle Socio- economic Group (MSG)	1.13	1.73	1.43
d) Lower Middle Socio- economic Group (LMSG)	0.81	1.37	1.09
e) Lower Socio economic Group (LSG)	0.32	0.68	0.50
Average	1.38	2.05	1.72
B) Commercial Solid Waste (CSW)			
a) Restaurant	9.50	12.11	10.8
b) Shops	0.96	1.07	1.00
c) Hotel/Guest House	6.9	7.60	7.25
d) Market/Shopping Mall (Commercial Unit)	1.30	1.44	1.37
e) Vegetable/Fish/Meat Market	4.20	6.02	5.11
Average	4.57	5.65	5.11
C) Institutional Solid Waste (ISW)			
a) Educational Institution	11.30	14.30	12.8
b) Religious Institution	4.10	6.65	5.40
c) Government Institution	14.60	19.50	17.05
d) Private Institution	4.04	7.10	5.57
Average	8.50	11.90	10.20
D) Municipal Service Solid Waste (MSSW)			
a) Street Waste	386.00	530.00	458.00
b) Drain Cleaning	282.00	342.00	312.00
Average	334.00	436.00	385.00
E) Industrial Waste			
a) Large Scale /Heavy Industries	403.00	467.00	435.00
b) Small Scale/ Cottage industries	71.00	83.00	77.00
Average	237.00	275.00	256.00
F) Medical Waste			
a) Medical Center/Hospital	41.00	47.00	44.00
b) Clinic/ Private Healthcare Center	20.00	25.00	22.00
Average	30.50	35.50	33.00

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 (0.57 Kg/day) by shop and maximum (13.12 Kg/day) by the restaurants. An average commercial unit generated 5.11 kg of waste per day (Table 3). The commercial waste generation rate by a person was found 0.38 Kg/day (Table 4).

The rate of institutional waste generation varied in different institution categories studied. The waste generation rate by an average institution was found minimum (5.4 Kg/day) by the religious institution and maximum (17.05 Kg/day) by the government institute and an average institution generated 10.2 kg of waste per day (Table 4). The institutional waste generation rate per person was 0.17 kg/day (Table 4). The rate of municipal service waste generation varied in different roads and drains studied. The average waste generation rate per kilometer road and drain was found 385 Kg/day (Table 3).

Industrial waste generation widely varied in both large-scale and small-scale industries studied. The average waste generation rate by a large-scale industry was found 435 kg/day and small-scale industry 77 kg/day and average industrial waste generation 256 kg/day (Table 3). The industrial waste generation rate per person was 0.17 kg/day (Table 4). The average medical waste generation was found 33 kg/day (Table 3). The medical waste generation rate per patient was 0.595 kg/day (Table 4).

Table 4: SW generation per person per day of major MSW sources

Major Sources		Rate (kg/capita/day)		
		Winter Season	Rainy Season	Average
A) Residential Solid Waste (RSW)				
a) Higher Socio- economic Group (HSG)		0.56	0.68	0.62
b) Upper-Middle Socio economic Group (UMSG)		0.36	0.47	0.415
c) Middle Socio- economic Group (MSG)		0.24	0.31	0.275
d) Lower Middle Socio- economic Group (LMSG)		0.17	0.24	0.205
e) Lower Socio economic Group (LSG)		0.06	0.14	0.10
	Average	0.28	0.37	0.323
B) Commercial Solid Waste (CSW)				
a) Restaurant		0.55	0.89	0.72
b) Shops		0.13	0.25	0.19
c) Hotel/Guest House		0.31	0.58	0.445
d) Market/Shopping Mall (Commercial Unit)		0.14	0.32	0.23
e) Vegetable/Fish/Meat Market		0.67	0.93	0.80
	Average	0.36	0.594	0.48
C) Institutional Solid Waste (ISW)				
a) Educational Institution		0.09	0.12	0.105
b) Religious Institution		0.04	0.06	0.05
c) Government Institution		0.28	0.36	0.32
d) Private Institution		0.17	0.25	0.21
	Average	0.145	0.2	0.17
D) Municipal Service Solid Waste (MSSW)				
a) Street Waste		0.12	0.165	0.1425
b) Drain Cleaning		0.088	0.107	0.0975
	Average	0.104	0.136	0.12
E) Industrial Waste				
a) Large Scale /Heavy Industries		0.29	0.37	0.33
b) Small Scale/ Cottage industries		0.18	0.24	0.21
Average		0.235	0.305	0.27
F) Medical Waste				
a) Hospital		0.61	0.75	0.68
b) Clinic/ Private Healthcare Center		0.45	0.57	0.51
	Average	0.53	0.66	0.595

4 Conclusions

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 study concluded the lack of resources such as; financing, infrastructure, suitable planning and data, and leadership are the main barriers in MSW management in Chittagong. Although the present MWM scenario is far from satisfactory, several findings and estimations in the

study reveal that there are sufficient opportunities to handle and improve the situation. Institutional/ organizational strengthening of the conservancy section should be given the top priority as without proper set-up, adequate manpower and equipment it will not be possible to realize the desired improvements.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Reference

1- Aderemi Adeolu O., Oriaku Ada V., Adewumi Gbenga A. and Otitoloju Adebayo A. Assessment of groundwater contamination by leachate near a municipal solid waste landfill. *African Journal of Environmental Science and Technology*. 2011, **5**(11):933-940.

2- Cointreau SJ (1982). Environmental management of urban solid wastes in developing countries: A project guide, Urban Development Dept, World Bank,

3- Doan PL. Institutionalizing household waste collection: the urban environmental management project in Cote d'Ivoire. *Habitat International*, 1998, **22**(1):27-39.

4- Burnley, S. J. A review of municipal solid waste composition in the United Kingdom. *Waste Management* 2007, **27**:1274- 1285.

5- Burnley, S. J., Ellis, J. C., Flowerdewc, R., Polld, A. J. and Prosser, H. Assessing the composition of municipal solid waste in Wales. *Resour.Conserv.Recycl.* 2007, **49**:264- 283.

6- Ahmed, S. A. and Ali, S. M. People as partners: facilitating people's participation in public–private partnerships for solid waste management. *Habitat International*, 2006, **30**(4):781–796.

7- Calo`, F. and Parise, M. Waste management and problems of groundwater pollution in karst environments in the context of a post- conflict scenario: the case of Mostar (Bosnia Herzegovina). *Habitat International*, 2009, **33**(1):63–72.

8- Halla, F. and Majani, B. Innovative ways for solidwaste management in Dar-Es- Salaam: toward stakeholder partnerships. *Habitat International*, 2003, **23**(3):351–361.

9- Mwangi, S. W. Partnerships in urban environmental management: an approach to solving environmental problems in Nakuru, Kenya. *Environment and Urbanization*, 2000, **12**(2):77–92.

10- Ogu, V. I. Private sector participation and municipal waste management in Benin city, Nigeria. *Environment and Urbanization*, 2000, **12**(2):103–117.

11- Zia, H. and Devadas, V. Urban solid waste management in Kanpur: opportunities and perspectives. *Habitat International*, 2008, **32**(1):58–73.

12- Thonart, P., Diabaté, S.I., Hiligsmann, S. and Lardinois, M. Guide pratique sur la gestion des déchets ménagers et des sites d'enfouissement technique dans les pays du sud. Canada: IEPF. 2005

13- Moghadam, M.R. A., Mokhtarani, N. and Mokhtarani, B. Municipal solid waste management in Rasht City, Iran. *Waste Management*, 2009, **29**(1):485–9.

14- Alam, A. K., M. M., Saha, S.K. and Rahman, M. M. S. Aspects of Solid Waste Management – A Case Study at Nirala Residential Area, Khulna. In: Ahmed, M. F., Tanveer, S. A., Badruzzaman, A. B. M. (eds.), *Bangladesh Environment*. Bangladesh Poribesh Andolon (BAPA), Dhaka-1207, Bangladesh. 2002:698–711.

15- Sujauddin, M., Huda, S. M. S. and Hoque, A. T. M. R. Household solid waste characteristics and management in Chittagong, Bangladesh. *Waste Management*, 2008, **28**:1688–1695.

16- Sharholy, M., Ahmad, K. and Mahmood, G. Trivedi RC. Municipal solid waste management in Indian cities. *Waste Management*, 2008, **28**(2):459–67.

17- Mor S, Ravindra K, Dahiya RP, Chandra A. Leachate Characterization and assessment of groundwater pollution near municipal solid waste landfill site. *Environ. Monit. Assess*.,2006, **4**: 325-334.

18- Hasan, S. Problems of Municipal Waste Management in Bangladesh: An Inquiry into its Nature. *Habitat ITNL*, 1998, **22**(2):191-202.

19- Enayetullah, I., Sinha, A. H. M. M. and Khan, S. S. A. Urban Solid Waste Management Scenario of Bangladesh: Problems and Prospects. Waste Concern Technical Documentation, Dhaka, Bangladesh. 2005, 18p.

20- Das S.R., Hossain Md. L., Salam M.A., Talukder S., Khanam M., Aktar F., Hossain M.K.. Generation and Assessing the Composition of Commercial Solid Waste in Commercial City of Bangladesh, *Indian Journal of Engineering*, 2013, **2**(5):36-41.

21- Salam M.A., Md. L. Hossain, S.R. Das, R. Wahab and M.K. Hossain. Generation and Assessing the Composition of Household Solid Waste in Commercial Capital City of Bangladesh. *International Journal of Environmental Science, Management and Engineering Research*. 2012, **1**(4):160-171.

22- Hossain Md. L., Das S.R., Rubaiyat A., Salam M.A., Uddin Md.K., Hossain M.K. Characteristics and Management of Institutional Solid Waste of Jamalkhan Ward, Chittagong, Bangladesh. *International Journal of Research in Management*. 2013, **2**(3):155-162.

23- Ashraf, M. A. Solid Waste Collection and Disposal in Chittagong: Problem and prospects. *Bangladesh Urban Studies*, 1994, **2**(2): 61-77.

24- Dhaka city Corporation (DCC) and Japan International Cooperation Agency (JICA). The Study on Solid Waste Management in Dhaka City. Prepared by Pacific Consultants International and Yachiyo Engineering Co. Ltd, Tokyo, Japan, 2004.

25- Hasan, G. M. J. and Chowdhury, M. A. I. Municipal waste management and environmental hazards in Bangladesh. *Pakistan Journal of Biological Science*, 2005, **8**(6):921–928.

26- IFRD and BCSIR. Refuse Quality Assessment of Dhaka City Corporation for waste to Electric Energy Project, The World Bank, Ministry of Energy and Mineral Resources, GOB, Dhaka, Bangladesh. 1998.

27- Rahman, M. M., Hossain, M. D., Badruzzaman, A. B. M., Ali, M. A. and Rahman, M. M. Characterization of municipal solid waste and preliminary environment impact assessment of collection and disposal wastes in Dhaka City. Bureau of Research, Testing and Consultation (BRTC), BUET, Dhaka. 1999.
28- Rahman, M. F. Closing the Organic Loop: Need for Managing Municipal Solid Waste: The Daily Independent, Bangladesh. January 03. 2000.
29- Rahman, M. A., Alam, M. S. and Al-Amin, M. Segregation of Biodegradable Solid Waste of Chittagong Metropolitan Area Based on Specific Physical and Chemical Properties. *Pakistan Journal of Biological Sciences*, 2006, **9**(3):460–464.
30- Salequzzaman, M., Awal, M., Alam, M. Willingness to Pay: Community Based Solid Waste Management and its Sustainability in Bangladesh. In: Proceedings of the International Conference 'The Future is here', RMIT, Melbourne, Victoria, January 15–19. 2001.
31- Chung, S. S. and Lo, C. W. H. Local waste management constraints and waste administrators in China. *Waste Management*, 2008, **28**(2):272–81.
32- World Bank. What a Waste: Solid Waste Management in Asia, Washington DC, USA. 1996, 1999, 43 pp.
33-Shekder Ashok V. Sustainable solid waste management: An integrated approach for Asian countries. *Waste Management*, 2009, **29**(4):1438-1448.

Authors' contributions

This work was carried out in collaboration between all authors. Authors Das S.R. and Hossain Md.L. designed & performed the study, wrote the protocol, and prepared the first draft of the manuscript in collaboration with Hossain M.K. The mastermind behind all the statistical analyses and literature searches was author Das S.R. and Talukder S. All authors read and approved the final manuscript.