Municipal Solid Waste Characteristics and Quantification as an Assessment of the Existing Waste Management System in the Cumilla City Corporation, Bangladesh

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Abstract

Solid waste generation and its management system were studied on different types of waste, generated from various sources such as households, hotels, bazaars, hospitals, streets, etc. of 27 wards at the Cumilla City Corporation (CuCC) area for 15 days. Both primary and secondary data on waste materials were collected for this project. The primary data collection process involved weighing waste by truckload while a questionnaire was used for secondary data collection. It was found that a total of 2,268 tons of waste was generated over the 15-day period, with food, vegetable, fish, and chicken residues making up 66%, paper products accounting for 10.64%, and polyethylene, plastic, and rubber wastes comprising 10.26%. The study revealed that approximately 79% of the waste materials were biodegradable, while the rest were non-biodegradable. Among the non-biodegradable waste, about 42% consisted of metals, 35% of glass, and 23% of plastic materials, all of which could be recycled. Additionally, there was a shortage of suitable dustbin systems, and most waste products were dumped in open fields. It was observed that 56% of people were unsatisfied with the existing waste management system of the city corporation, and only 38% were concerned about the environmental, health, and other impacts of these solid wastes. Thus, this research indicates that CuCC's current waste management system is not up to date. The system needs to be improved, and public awareness should be raised to protect both health and the environment from the harmful effects of solid waste.

Keywords: *Municipal solid waste, Cumilla City Corporation, Waste management system, Waste quantification, Waste characterization*

1. Introduction

One of the considerations influencing environmental sustainability is the necessity for a suitable policy, legislation, and a realistic and successful solid waste management (SWM) strategy [1]. In most cities worldwide, ineffective discharge and administration of solid waste is a clear source of ecological harm. The management of waste, including its production, storage, collection, transportation, processing, and disposal, should be handled in a way that maximizes benefits to the environment, public health, the national economy, biodiversity, and the local ecosystem [2]. Global urban solid waste generation was 1.6 billion tons in 2002, and it is predicted to steadily climb to 2.2 and 4.2 billion tons by 2025 and 2050, respectively, posing a huge concern for the future world. [3–4]. The volume of solid

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waste is increasing daily due to population growth, urbanization, economic development, and rising living standards. [5]. The disposal of municipal solid waste management (MSWM) faces a variety of significant challenges in both developed and developing countries [6–7]. There are many benefits for the environment through the effective management of solid waste. In developing countries, multifaceted researchers discussed improper SWM in their respective cities [8–14]. Different studies show that the major source of MSW is household waste, as well as market and street waste [15–16]. SWM has been identified as the most difficult task for developing countries at the national level [17]. Total waste generation in the municipal area is proportional to the population size and their average income level. Moreover, factors such as education level, community, and public behavior, and climate can influence the composition and amount of waste generated [18]. As a result, appropriate waste management is a critical concern for the future globe, as well as a threat to sustainable growth.

Improper management of municipal solid waste (MSW) affects public health as well as the environment and leads to biological degradation [19–20]. Both surface and groundwater are contaminated by the dumping of hazardous and non-biodegradable solid waste. Humans can suffer from congenital malformations, neurological diseases, nausea and vomiting, etc. The workers involved in waste management and rag pickers suffer from long-standing diseases [21].

The majority of MSW in Bangladesh is deposited in open landfills or lower land regions, as well as near ponds, lakes, rivers, and other environmentally sensitive locations. This type of improper SWM has serious health and environmental consequences [22]. City dwellers have the right to expect a clean, healthy, and environmentally sustainable city to live in. Municipalities typically fund SWM through municipal taxes for this purpose. However, a lack of funds, skilled staff, structured work, and a lack of knowledge and incompetence lead to solid waste mismanagement [23]. There are several methods for managing solid waste effectively. When it comes to waste management, the advanced alternatives include trash minimization, waste reuse, waste-to-energy conversion, and recycling. Taking these steps can help to reduce solid waste generation, minimize its impact on the environment and human health, and decrease the need for treatment processes and landfill space. Reducing waste generation lowers environmental risks and supports the advancement of sustainable development. [24].

Household waste generation is affected by a variety of factors, including family size, culture and attitude, food-producing season, lifestyle, and so on [25]. A community must understand how much SWM is generated in their area and its characteristics in order to effectively manage solid waste and address the challenges it poses. In Cumilla City Corporation (CuCC), it is critical to raise awareness among people from all sectors about the effects of open dumping of solid waste on both humans and animals, as well as the ecosystem, in order to build a biologically safe environment. In this study, we present the current state of SWM in CuCC, focusing on quantifying and categorizing waste based on factors such as waste types, dumping sites, and disposal processes. Moreover, public concerns, practices related to MSWM, and satisfaction levels were evaluated through a survey.

2. Materials and Methods

This section primarily focuses on the study area and the data collection process.

2.1. Study area

CuCC is a city in Bangladesh that was founded in 2011 under the Chattagram division. It has a total land area of 53.04 square kilometers. This city is flanked on the north by Brahmmanbaria district, on the south by Chadpur, on the east by Dhaka, and on the west by Tripura. It currently has a population of roughly 5 lakh people. CuCC is divided into 27 wards. Among all the CuCC's obligations, the management of solid waste generation due to population expansion is the most difficult [27]. This survey was done over 15 days across the municipal corporation's 27 wards (Figure 1).

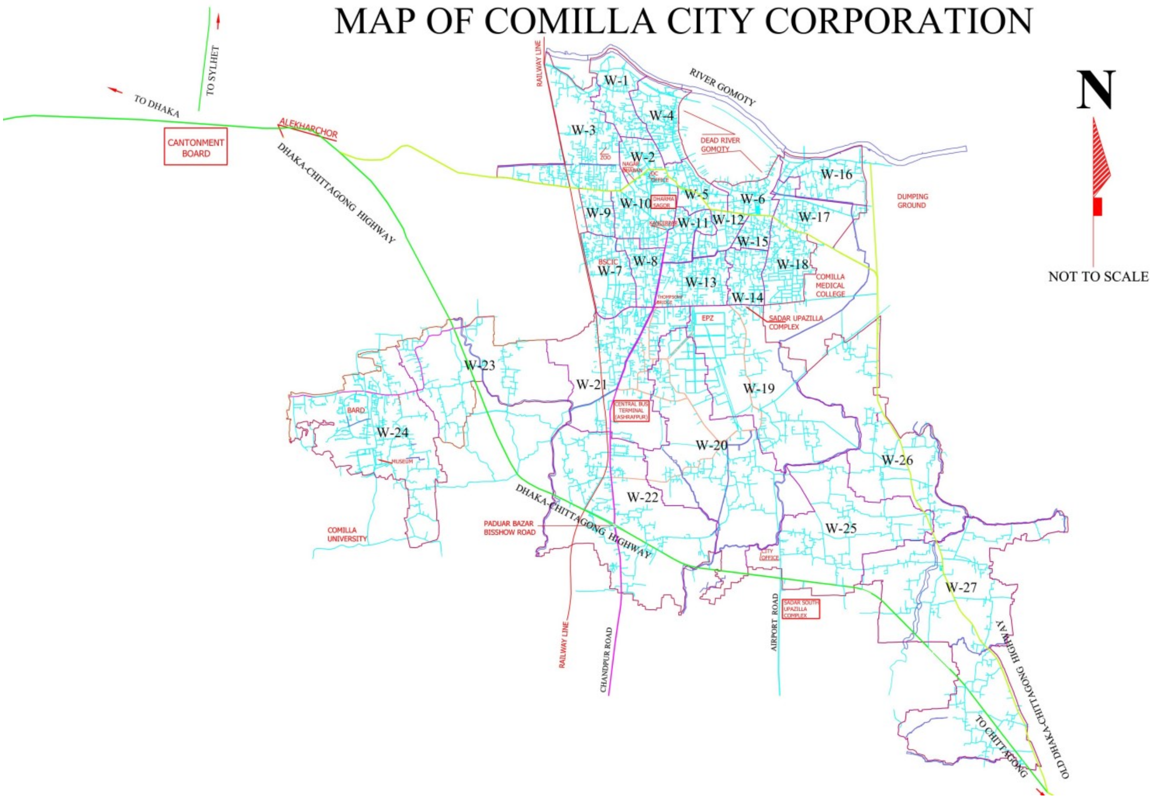

Figure 1. Sampling area of different wards of CuCC (Source: CuCC Office)

2.2. Data collection and analysis

This strategy employed both primary and secondary data. Primary data came from the total weight of garbage collected from the principal source during the survey, whereas secondary data came from a variety of sources, including government reports, scientific and journalistic articles, books, and numerous web resources. To achieve the key objective of this report, primary data were gathered via a survey of 27 wards in the CuCC. A total of 100 respondents were randomly selected using the random sampling technique, and data were collected using structured and semi-structured questionnaires. The questionnaires gathered general information on economic conditions, family members, and their SWM system (such as how they collected and disposed of waste, their waste dumping facilities, their waste management monitoring system, and so on). In addition, the questionnaire included questions on the impact of environmental challenges and sustainable development.

3. Results and discussion

3.1. Demographic and socio-economic profile of the study area

A substantial proportion of CuCC city citizens were employed in various sectors, including teaching, banking, engineering, government services, and business, among others. The income levels of the residents varied, with the area being home to individuals with low, middle, and high incomes. This neighborhood consisted of both permanent and temporary residents. Low-income individuals typically lived in tin-roofed houses, while middle- and upper-income residents resided in brick-built buildings. The results and discussion section is divided into four sections: the existing SWM system, waste-generating numbers, solid waste composition, and solid waste features.

3.2. Existing waste management in CuCC

The waste management system was found to be outdated and incompatible with modern technology and the city's growing population. This was because of insufficient facilities and a lack of awareness among city people. Rather than throwing their garbage in the bin, the residents dumped it in the surrounding open areas, drains, roadsides, ponds, rivers, and so on. The following sections outline the current waste management techniques used at CuCC.

3.2.1. Storage

People use different storage systems to stock their household waste such as waste buckets, tins, cans, plastic bags, etc. The frequency with which they disposed of their waste daily or weekly depended on the amount of waste generated in that house. Figure 2 shows the percentage of different storage systems used by city dwellers. People in the city area are more likely to use a wastebasket (51 %) and an old bucket (31 %) as their primary means of storing household waste.

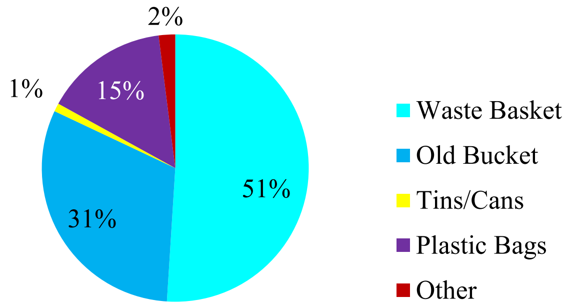

Figure 2. The storage system of wastes in CuCC

3.2.2. Collection

CuCC has several trucks by which they collect solid waste from different dustbins generated by households, hotels, small shops, shopping malls, etc. from every ward. During the study period, each truck performed 3 trips per day. Household and hotel waste was collected by rickshaw vans, which were then emptied into nearby dustbins. The waste was subsequently loaded onto trucks and transported to 'MoylaKhuli,' the local dumping area – Figure 4) located in Jogonnathpur, Comilla. Table 1 shows the types of vehicles used to transport waste.

Table 1: Transportation system for waste collection

Types of Vehicles	Capacity (tons)	Amount
Large Truck	5	1
Medium Truck	3	16
Small truck	1.5	7
Rickshaw vans	0.5	150

3.2.3. Disposal

Most people in Bangladesh dispose of their waste in open spaces such as public places, roadsides, rivers, canals, ponds, etc. This same practice was prevalent for the people living in the CuCC area too. The disposal system used by the city dwellers is shown in Figure 3. Finally, local authorities collected waste from public bins and transported it to the final disposal site in Jogonnathpur, Cumilla (Figure 4).

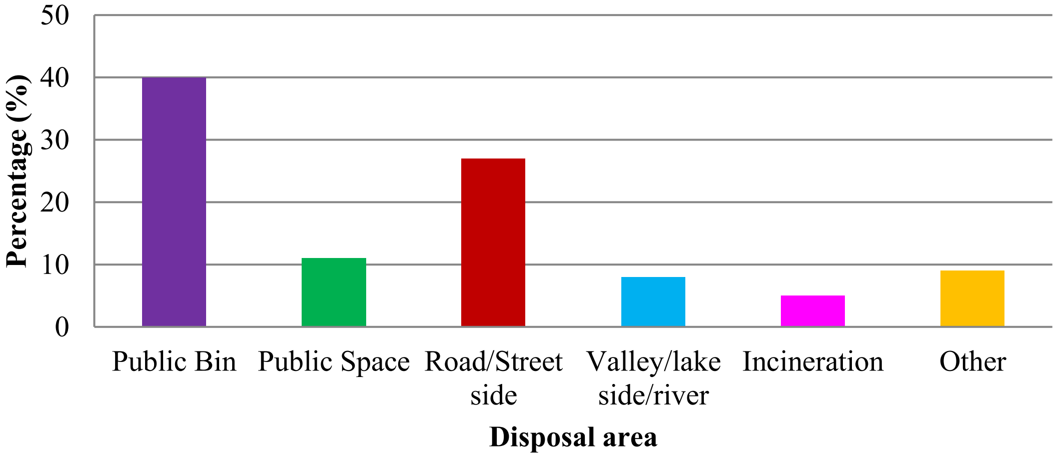

Figure 3. Waste disposal methods

Figure 4. Disposal of solid waste in the landfill in Jogonnathpur Moylakhuli (Location- Jogonnathpur, Cumilla)

3.3. Quantities of waste generation

The vast majority of the population of CuCC generates a huge amount of solid waste. Approximately 2300 tons of solid wastes were generated in CuCC within a 15-day period (Table 2). Residential and commercial wastes made up a large proportion of the TWG in CuCC which is shown in Table 2. The composition of this solid waste was varied. Figure 9 illustrates the percentage breakdown of its components.

Figure 5. a) Collecting hospital waste b) weighing the waste c) segregation of waste (Location- Cumilla Central Hospital and College, Kandirper, Cumilla)

Innovation Sheba organization conducted a project on Medical Waste Management of CuCC. Under this project, a 5-ton open truck collected medical waste from different hospitals and diagnostic centers every day shown in Figure 5. Approximately 2.98 tons of medical waste was generated every day from hospitals and diagnostic centers (Table 2). From the segregation analysis of the medical waste, the different components of the waste were found as displayed in Figure 5.

In CuCC, there were 11 big and small bazaars (namely including Rajgonj, Chackbazaar, Tomsom Bridge Bazaar, Ranir Bazaar, Badshahmia Bazaar etc.). They produce lots of waste every day (Figure 6). CuCC conducted the management of these wastes. Approximately 18.57 tons of waste were generated every day by different bazaars of CuCC which is shown in Table 2, and the composition of waste generation is shown in Figure 11.

Figure 6. Collecting, weighing, and segregation of bazar waste (Location- Rajgonj bazar, Cumilla)

Figure 7. Gathering of street waste (Location- Kandirper, Cumilla)

3.4 Variation of waste generation for different income families

A total of 1,973.56 tons of residential waste was generated by city residents over the 15-day period, as shown in Table 2. Middle-income families contributed 50% of the total household waste, while low-income and high-income families accounted for 35% and 15%, respectively, as illustrated in Figure 8.

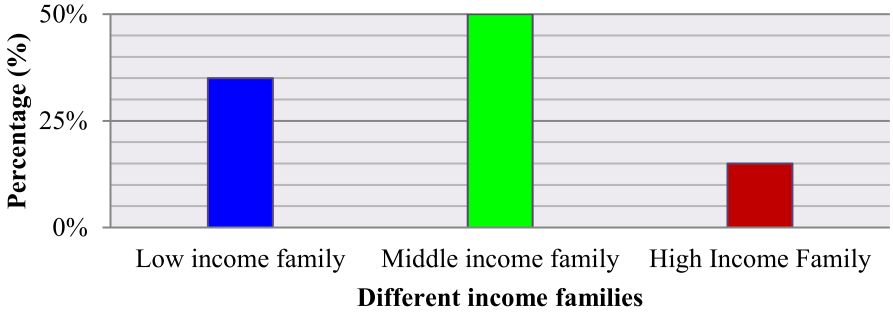

Figure 8. Waste generation by different income families

3.4.1. Chart of quantities of waste generation

In CuCC, workers were working in the street collecting street waste (Figure 7). The total waste generation of the street is given in Table 2 and the proportion of waste is in Figure (9-12).

Table 2. Table of quantities of waste generation.

Type		Number		Weight of waste			
Waste	Vehicles (ton)	Truck	Loads (trips/trucks/day)	(kg/truck/trip)	Average (ton/truck/day)	Total average (ton/day)	Total (ton/15 days)
WaRC	3	16	3	2072	6.216	99.456	1491.84
	5	1	3	3453	10.359	10.359	155.38
	1.5	7	3	1036	3.108	21.756	326.34
WaB	5	1	2	2018	4.036	4.036	60.54
	3	6	1	2421.6	2.422	14.53	217.94
WaHD	5	1	1	2980	2.98	2.98	44.70
WaS	3	1	1	745	0.745	0.745	11.17
TWG (WaRC + WaHD + WaB + WaS) =						**153.862**	**2267.92**

N. B. WaRC, WaB, WaHD, and WaS represent wastes of (a) Residential and Commercial wastes b) bazar c) hospital and diagnostic centers d) streets e) Total waste generation

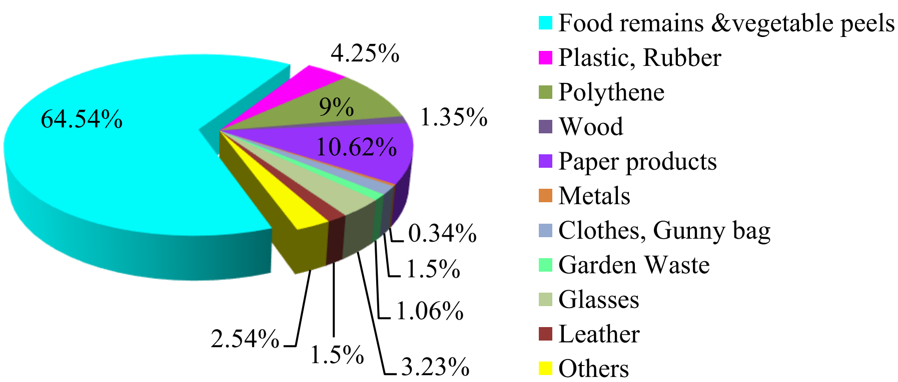

Figure 9. Proportion of Residential waste

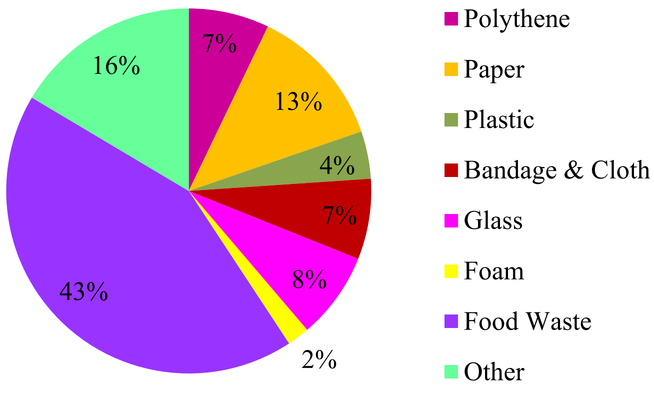

Figure 10. Proportion of components of the medical waste

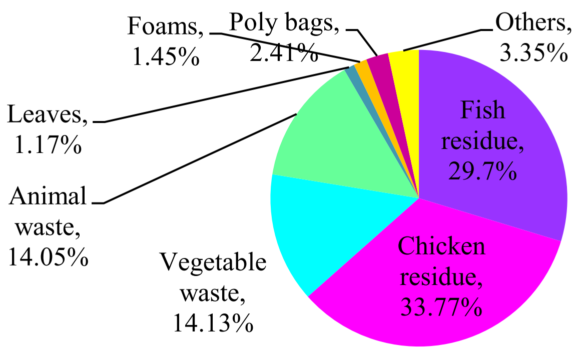

Figure 11. Proportion of Bazaar Waste

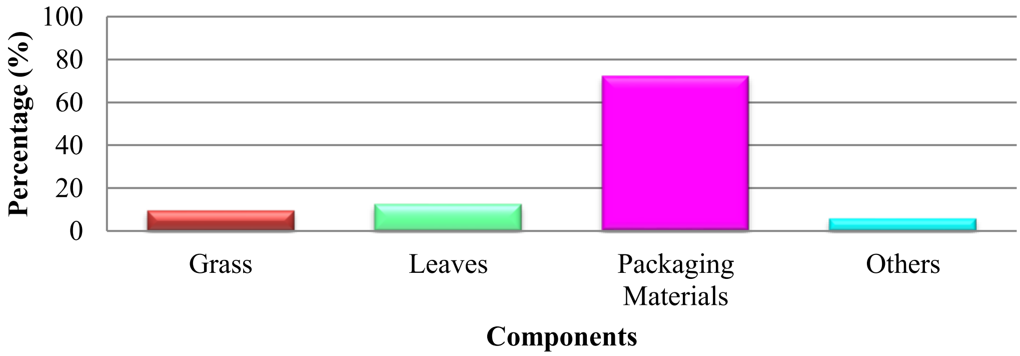

Figure 12. Proportion of street Waste

3.5. Composition of solid waste

The composition of solid waste varied depending on the source of collection. Figure 13 shows the waste composition, which was separated into distinct categories and independently weighed by different waste components. The percentage of waste components found from the segregation analysis of residential, bazaar, hospital, and street garbage are displayed in Figure 13.

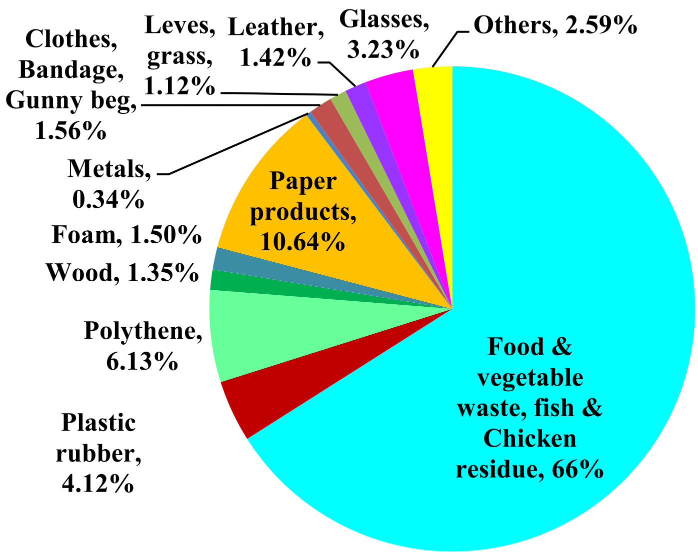

Figure 13. The total average proportion of waste generation in CuCC

3.6. Characteristics of solid waste

Waste segregation revealed two main types: biodegradable and non-biodegradable. Among the non-biodegradable waste, some materials were recyclable.

3.6.1. Biodegradable and non-biodegradable waste

Organic garbage, highly biodegradable, constitutes the majority of home and commercial waste. Approximately 79% of the biodegradable waste consists of vegetable matter, with the remaining portion made up of paper, grass, wood, and cloth. The quantities of paper and cloth were minimal, each comprising just 1%, while grass and wood also accounted for only 1%. Non-biodegradable waste consisted of 19% plastics, metals, and glass, with other materials making up 2%, as shown in Figure 14.

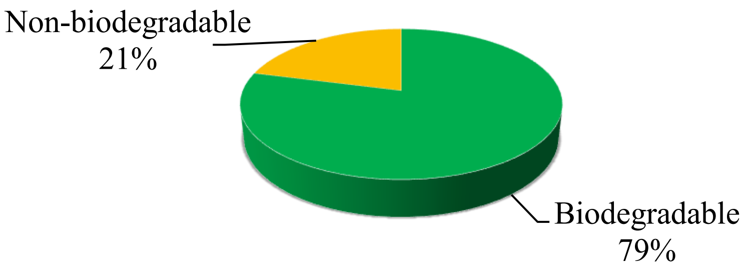

Figure 14. Biodegradable and Non-Biodegradable Waste

3.6.2. Recycling

Among the non-biodegradable waste, some could be recycled. This included poly bags, plastic materials such as plastic bottles, glass materials, bamboo materials, metals, etc. Figure 15 shows that about 35% of glass materials, 42% of metals, and 23% of plastic materials were used as recycling matter which is evident from the field data.

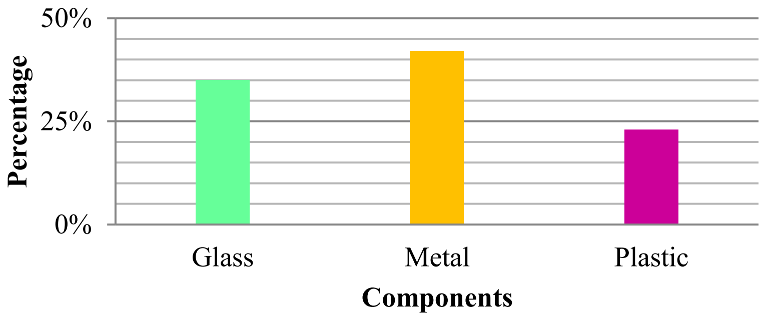

Figure 15. Recycling Matters

3.7. Other observation

From the field data, there is also some concerning information regarding SWM gathered, as reported in the following subsections.

3.7.1. Reason for the open dumping of household waste

Figure 16 shows that due to the lack of adequate-sized dustbins, poor bin conditions, and insufficient availability, city dwellers often resorted to dumping waste in open fields or water bodies. According to Figure 16, only 20% agreed that the dustbins were of adequate size, while 40 % said there was a lack of available dustbins, 25% said that dustbins were not in good condition, and 15 % attributed the issue to their lack of awareness. Moreover, the government has not effectively enforced rules and regulations regarding waste disposal.

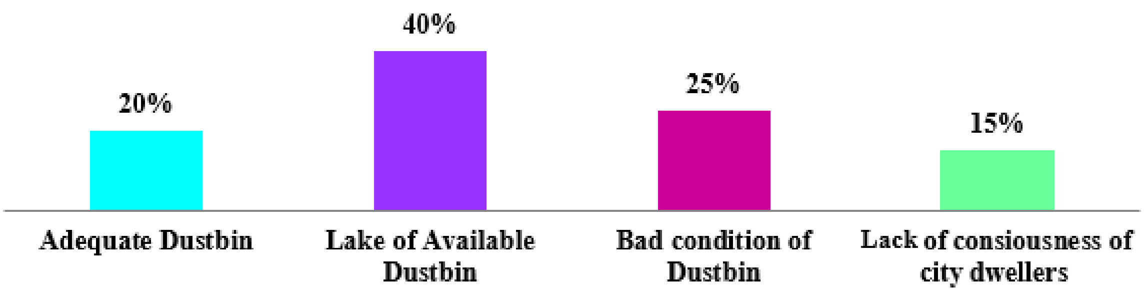

Figure 16. Reasons for open dumping

3.7.2. Practise of SWM

According to the field data, only 35% of respondents practised SWM, while the remaining 65% were unconcerned about the issue (Figure 17). Most respondents indicated that SWM should not be practised.

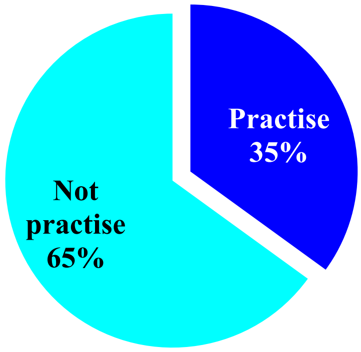

Figure 17. Practice of solid waste management

3.7.3. Concerned environmental pollution and health impact due to solid waste

Figure 18 depicts the municipality's level of concern about environmental contamination and the health consequences of SWM. It demonstrates that only 42% were concerned, but the majority, 58 %, were not.

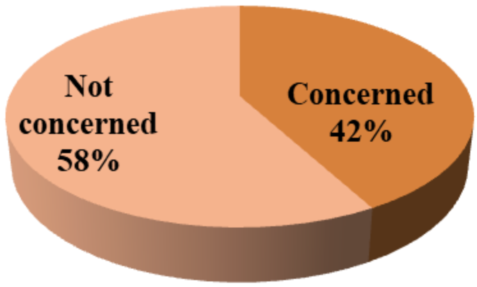

Figure 18. Environmental pollution and health impact due to solid waste.

3.7.4. Level of satisfaction with the present SWM system

Figure 19 shows that 10% of respondents had negligible satisfaction, 34% were moderately satisfied, and the majority (56%) were not confident with the present SWM system of CuCC.

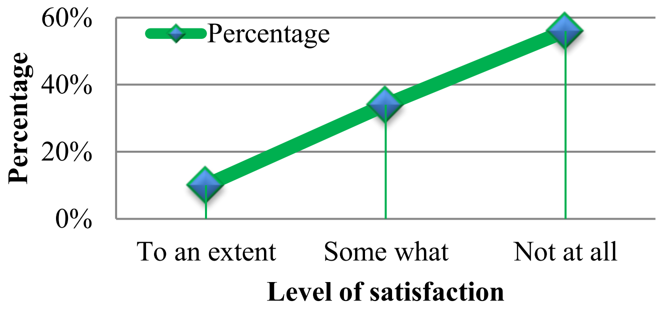

Figure 19. Satisfaction level of the present SWM system

4. Present challenges and recommendations for SWM in CuCC

The current study identifies several factors contributing to the poor performance of MSWM in CuCC, similar to other developing nations. These issues, along with recommendations for improvement, are outlined below.

i) Because of design constraints, rickshaw vans are not suited for the primary collection of MSW from households.
ii) Closed trucks will be more compatible for transporting waste than Open trucks to reduce air pollution within the city.
iii) There are only a couple of transfer stations. Transfer facilities should be positioned across the predominant collection routes, and collection sites should be rebuilt in such a way that the leaching of liquid waste does not end up in waterways.
iv) Waste separation techniques are still not adopted at the source or the dumping site. Furthermore, only metals and plastics are separated locally, but polythene and other hazardous materials are not.
v) Inadequate legislative implementation creates possible barriers to the formalized recycling sector. Again, Bangladesh's waste industry inventories are deplorable and/or insufficient.
vi) For sustainable waste sector management planning, a chronological sequence of records should be created.
vii) The effects of ecological evaluations have been limited to local ecological contaminants and water source contamination, which needs to be investigated at frequent intervals using the latest technological advances.
vii) Finally, there is a lack of awareness among residents and municipal authorities, as well as a lack of information about how to effectively manage waste. As a result, a collaborative awareness program between city citizens and municipal authorities, as well as an implementation of optimized MSWM and recycling methods, will pave the way for a more sustainable City Corporation.

5. Conclusion

This study shows that the present scenario for the waste management system in the CuCC is not satisfactory. A total of 2,268 tons of solid waste was generated over a 15-day period. The waste comprised mainly 66% of food and vegetable waste, 10% of paper waste, 6% of polythene waste, 4% of plastic and rubber, 1.4% of wood, and 3.2% of glass waste. In addition, 1.5% consisted of foam, 1.4% of leather, 1.5% of clothes, and 2.6% of other waste types such as gunny bags, garden waste, dust, etc. Of the total waste, about 79 % was biodegradable and 21% was non-biodegradable waste. About 35% of glass materials, 42 % of metals, and 23% of plastic materials were recycling matter. Another finding showed, only 20 % of the studied people agreed that they had adequate dustbins. Moreover, only 35% of the respondents were practising SWM. With the environmental pollution and health impact due to SWM, only 42% were concerned. The study also revealed that 56% were not satisfied with the present SWM system of CuCC. Thus, proper implementation of the management system of solid waste can satisfy the people of the city and can reduce the generation of solid waste, which will help achieve the goal of sustainability.

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Conflict of interest

We declare no conflict regarding the publication of the study.

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