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IMPACT OF ECONOMIC AND SOCIAL FACTORS ON MUNICIPAL SOLID WASTE GENERATION AND COMPOSITION IN KHULNA CITY, BANGLADESH

Jawad Bin Rashid[1], Riday Khandaker[2]

[1]University of Asia Pacific, Dhaka – 1205, E-mail: 20205030@uap-bd.edu
[2]University of Asia Pacific, Dhaka - 1205, E-mail: 20205027@uap-bd.edu

ABSTRACT

Municipal solid waste (MSW) management is one of the most serious challenges in urban areas facing crises in the third world, especially in a rapidly urbanizing city, such as Khulna City, Bangladesh. The aim of this review is to compile the results of recent studies, specifically on household waste generation, characterization and socioeconomic factors. According to studies, biodegradable waste makes up 81% of household trash, and production increases with increasing income. Consumption patterns lead to increased generation of non-biodegradable waste with higher income households producing greater quantities of plastic and paper. The main pillars which contribute to reduce plastic leakage and ensure sustainability are source separation and diversified waste management strategies. The authors challenge the assumptions behind resource recovery industries and outline the need for context-specific integrated MSW management systems to accommodate socioeconomic dynamics, which can strategically inform and direct policy and infrastructure development for efficient and environmentally sustainable urban waste management.

INTRODUCTION

Municipal Solid Waste (MSW) is increasingly recognized as one of the most serious and urgent issues facing municipalities around the globe, especially those in the developing world. There is another reason for this waste management problem in these regions such as rapid urbanization, population growth, and industrialization and many others. Economic development coupled with a change in consumption patterns has increased the waste generated, whereas cities are finding it difficult to manage, process and dispose of the waste in an environmentally benign manner. Household waste accounts for a large proportion of MSW, which means that understanding characteristics of household waste generation and the factors that impact it deserve special attention.

Urban MSW management has a special challenge in the developing world, one such case is Khulna the 3rd largest urban agglomeration in Bangladesh. Over 1,000 tons of waste is produced in Khulna a day, of which, more than 80 percent come from household level. However, the enormous amount of waste generated is not being met by the existing waste management system of the city. It is plagued by insufficient infrastructure, low source separation rates, and inefficient recycling. This means that a lot of household waste is not sorted or not recycled, which is part of environmental pollution and a waste of resources.

The characteristics (composition and generation) of household waste is influenced by socio-economic factors such as household income, family size and education of the head of household in Khulna. Due to their consumption of packaged goods and disposable items, high-income households have a tendency to source a higher percentage of non-biodegradable waste, such as plastics, paper and metals. On the other hand, organic waste, like food scraps and yard waste, is more often produced by lower-income households, primarily because they are healthier and eat more responsibly and consume fewer packages. These differences in waste composition show the necessity of waste management strategies at different scales, due to the high variability on socio-economic context through the city.

In this paper review we find most current researches of MSW in Khulna City emphasizing characteristics of how household waste generation as well as socio-economic factors determining this pattern. The study reveals significant gaps in the current waste management systems, such as inadequate waste separation at the source, lack of awareness among people, and unavailability of effective recycling systems. Abstract concerns over solid waste management have grown due to the

rapid urbanization of many countries, especially in developing regions such as Asia, where waste generation rates continue to rise. The paper recommends solutions for sustainable waste management, including source separation at the household level, enhanced waste segregation infrastructure, and recycling systems that can help to divert waste away from landfills. Waste management strategies not only mitigate the environmental consequences of waste disposal but also advance the Sustainable Development Goals (SDGs), especially to responsible consumption and production patterns (SDG 12) and to combat climate change (SDG 13).

To summarize, this review established a necessity for integrated approach towards waste management in Khulna as well as other developing regions that takes into account the socio-economic issues influencing MSW generation, challenges associated with current disposal practices, and sustainable options to reduce the environmental footprint of MSW.

LITERATURE REVIEW

Municipal solid waste characterization, Dhaka, Khulna, Chittagong Summary: A synoptic assessment of municipal solid waste (MSW) characterization level in the major cities of Bangladesh (Dhaka, Khulna, & Chittagong) was performed, in the form of a review. The paper identified biodegradable waste as constituting 75–80% of the MSW stream – indicating the larger share of organic materials in waste streams. Urban centers simply do not have sufficient solid waste management infrastructure or recycling initiatives in place, leading to vast environmental and public health problems, the study stated. They promoted waste to Resource approaches such as composting and energy recovery as some of the solutions needed to handle the organic portion of the waste stream. Sustainable waste management systems should also integrate community participation and policy reforms (Alamgir et al., 2023).

Waste Characterization, Quantification, and Socio-economic Effects (2023) Biodegradable waste accounts for 81 per cent of the waste stream, and higher-income households produce more non-biodegradable components, such as plastics and paper, the study found. With rates from 0.312 kg/cap/day for low-income households to 0.652 kg/cap/day for high-income households, a strong relationship correlating to income was also found for waste composition. Discussing the recommendations Eco-Social Development Organization (ESDO) said that the mixed waste collection system is not efficient enough to recycle the waste and recover resources. It is proposed to separate waste into biodegradable, recyclable, and other components prior to collection, in the most practicable way, as differentiating waste at the source is one of the main drivers globally in terms of promoting recycling and resource recovery. These practices, coupled with public awareness campaigns, can also improve waste management and facilitate the sustainability objectives of solutionCtx (Noman et al., 2023).

Islam (2023) assessed the status of waste collection and management systems in Khulna City and the role of NGOs and CBOs. It concluded that although NGOs and CBOs play an important role in collecting C&DW at the household level, when source separation is not practiced there are implications for recycling and environmental risk (Budhi et al.2018). One of the basic principles of Islam is that if a certain waste can be segregated at the source properly, it will reduce efficiency and costs in transport and disposal. It identified the low level of public participation and lack of synergy among different market players as significant constraints, recommending public education strategies and more stringent enforcement of waste management regulations (Islam et al., 2023).

The Case of Municipal Solid Waste — Setshwenyo Omphile, Kgetseyamore Letshwenyo, 2023 | ScienceGate Conchiarano et al were most interested in investigating source-separated collection systems that could potentially capture an abundance of recyclables, such as plastics, paper and metals, that would otherwise be lost in mixed waste streams. In terms of source separation implementation challenges in the developing world, they cited logistical barriers like the absence of infrastructure and the need for community engagement . The authors recommended implementing a phased rollout with initially pilot projects in selected urban neighborhoods to test feasibility and gain public confidence in source separation. They concluded that sustainable waste management practices should be achieved through coordinated efforts between local government bodies, the private sector, and the communities they serve (Letshwenyo et al., 2023).

METHODOLOGY

The study on waste generation and composition, together with the socioeconomic drivers of household municipal solid waste (MSW) generation in Khulna City, Bangladesh, was initiated to obtain an in-depth analysis of the waste profile and potential drivers affecting waste management modalities. The research used a stratified sampling method in which wards were picked from Khulna

City to achieve coverage of various socioeconomic conditions of the city. Ward based classifications were done in to 9 groups on the basis of UNDPPoverty Score, which indicates the relative level of poverty and inex that prevails within various parts of the city. Within these categories, one ward was randomly selected from each of the 31 wards of Khulna to include a broad spectrum of income and socio-economic contexts.

The study covered a total of nine wards, and comprised 675 households. Households were grouped in five income groups with low, medium-low, medium, medium-high and high income, respectively, in order to have an adequate range of groups considering the diversity in waste generation and composition of the lowest to highest socioeconomic groups. We used structured questionnaires that were administered to the head of each household to collect relevant data on waste management practices, sociodemographic, and household characteristics. The survey gathered information on the types and quantities of waste generated, household incomes, family sizes, education levels, and various other socio-demographic factors that may affect waste management behavior.

A major aspect of the study was waste segregation, where households received separate bins for compostable waste and non-biodegradable others. The biodegradable bin was for organic waste, and the other non-biodegradable bin was for things like plastics, paper, glass, and metal. The separation of waste was carried out over 14 days (samples were collected every second day). This frequent collection facilitated the investigation of temporal variations in waste generation and ensured representation of all forms of waste discarded for the study.

After collation of the waste, it was shipped to a lab. The waste was categorized into all the materials that make it up, namely plastics, paper, organic waste, glass, metals, textiles, and other debris. It is a manual sorting process with material identification accuracy. In order to develop a detailed understanding of the characteristics of the waste, several key parameter measurements were taken through laboratory analyses. These factors include the moisture content, particle size distribution and bulk density of various waste constituents, as these affect the efficiency of various waste management operations like composting, recycle or incineration.

Besides the composition analysis of the waste, statistical methods were also used to assess the relationships between the waste generation and different socio-economical parameters. We used multivariate analysis on data from households to observe the connection between family size, income, education, and waste generation. Through this, we understood the role of demographic factors in explaining the types/volumes of waste generated in the city. To gain understanding at the urban level, this study also amassed data for Khulna City, by extrapolating the results obtained from the sampled wards at the urban level.

The methodology included quality control measures throughout data collection and analysis processes to ensure that the results were reliable and valid. To avoid mistakes, data entry and cleansing procedures were rigorously adhered to, while statistical tests were conducted to verify the significance of correlations observed in data. The study received ethical approval (see results) and we informed each participating household of the aim of our data collection and ensured individual confidentiality (see results).

The method that encompasses field surveys, waste composition analysis, and laboratory analyses provided a basis for a holistic assessment for Khulna waste management practices. Results inform on the potential composition and generation of MSW in the city, the socio-economic determinants of waste behaviour, and provide a strong platform for evidence-based policy recommendations to enhance waste management practices and promote sustainable development in the region.

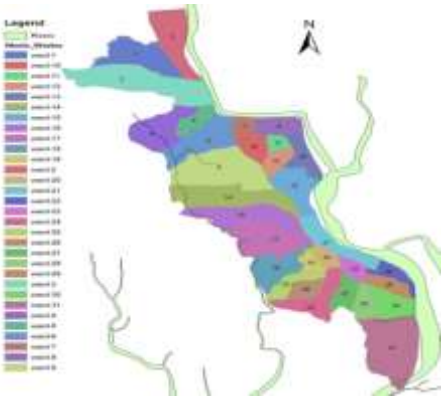

Figure 1 31 KCC WARDS

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EQUATION & FIGURE

Bulk Density: The bulk density (DDD) of municipal waste was calculated as:

$$D=\frac{M}{V} \quad (1)$$

M= Net weight of the waste sample (kg)
V= Volume of the container (m3)

Moisture Content:

$$M=\frac{A-B}{A}\times 100 \quad (2)$$

A=Initial weight of the waste sample (wet weight) (kg)
B=Final weight of the dried waste sample (kg)
Population and Sampling Extrapolation:
Waste Generation Rate (kg/day)=∑(WGR (kg/cap/day)×Population of Income Group) (3)
WGR (kg/cap/day)= Waste generation rate per capita per day based on income.

Table 1 Overview of the equations

Parameter	Equation	Result
Bulk Density	$D=\frac{M}{V}$	Biodegradable: 553.8; Plastic: 43.62
Moisture Content	$M=\frac{A-B}{A}\times 100$	Biodegradable: 74.86%; Plastic: 16.54%
Water Generation Rate	$WGR(kg/cap/day)=\frac{\text{Total Waste Collected}}{\text{Population}\times\text{Days}}$	Low Income: 0.312; High Income: 0.652
Source Separation (Plastic)	$\text{Reduction}=\frac{\text{Mixed Fraction}-\text{Seperated Fraction}}{\text{Mixed Fraction}}$	36.92% reduction (Mixed: 4.74%; Separated: 2.99%)
City Wide Waste Generation	Total Waste=∑(WGR×Population)	641 tons/day across Khulna City

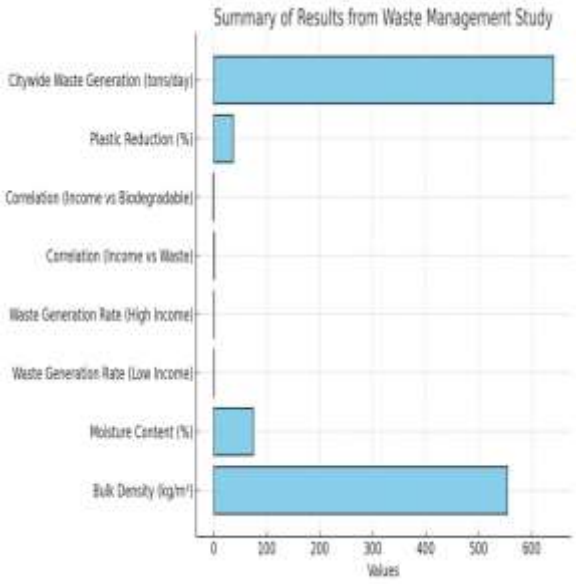

Figure 2 Summary of Waste Management Study

Compare the amount and composition of waste across three income groups: low-income, middle-income, and high-income. Key observations:

Waste Generation Rate (kg/cap/day) (blue bars): Tendency to increase with increasing level of income—indicating higher-income groups will create more waste, per capita.

Biodegradable waste (%) (green bars): Comprising most of the waste of all income groups, higher average sustaining approximately (~70-80%).
Plastic Waste (%) (red bars): Although the percentage is low across all income levels, it exists in each category.
Paper Waste (%) (purple line): Rises steadily across income groups, peaking at High-Income, demonstrating that wealthier households generate more paper waste.

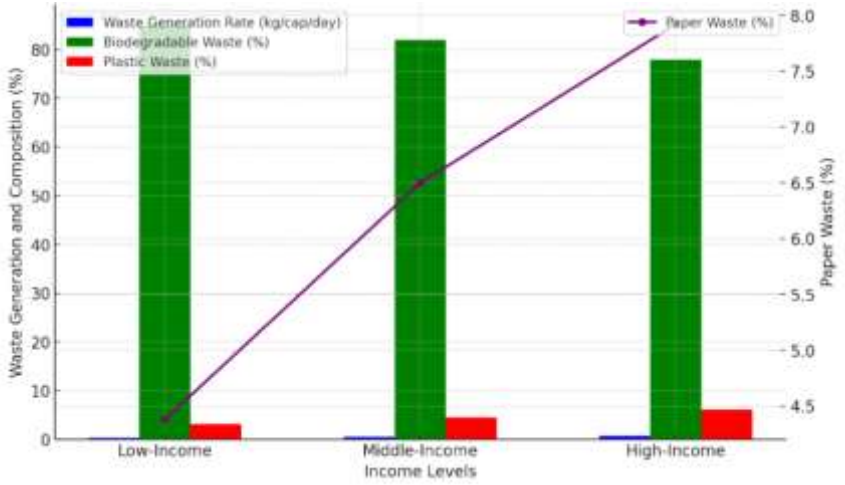

Figure 3 Waste Generation & Composition Analysis by Income Level

Table 2 Summarizing the waste generation and composition across different income levels

Parameter	Low Income	Middle Income	High Income	Average
Waste Generation Rate (kg/capita/day)	0.312	0.469	0.652	0.469
Total Daily Waste in Khulna (metric tons)				641
Biodegradable Waste (% of total)	85%	82%	78%	81%
Plastic Waste (% of total)	3.15	4.5%	6.08%	4.74%
Paper & Cardboard (% of total)	4.38%	6.5%	7.92%	6.67%
Other Recyclable Waste (Glass, Metals, etc.)	0.5%	1.0%	1.8%	1.1%
Waste Generation Peak (Weekend)	0.51 kg/cap/day			Higher on Saturday
Correlation (Income vs. Waste Generation)	r= 0.997			Positive Correlation
Source Separation Potential	Low	Medium	High	Medium Potential

CONCLUSION

This study is a comprehensive assessment of municipal solid waste management in Khulna city, Bangladesh, and particularly household waste generation, composition and socioeconomic drivers. The results emphasize that biodegradables account for the highest proportion of MSW (81%), while income levels were found to significantly correlate to waste generation and composition. Households in the highest-income group generate more plastic and paper waste, whereas waste in the lowest-income group has a larger proportion of biodegradable waste.

Waste management in Khulna follows a mixed practice that involves less expensive CBOs and NGOs for waste collection, although this model is hampered by ineffective source separation and lack of infrastructure. The results also highlight the efficiency in waste management that further separation at the source coupled with recycling can provide. Through source-separated waste collection promotion, waste segregation recycling facilities provision and public education interventions, Khulna can move significantly closer toward sustainable waste management.

Additionally, the findings of this research offer an essential basis for policy-makers to design specific interventions. In urban areas such as Khulna, addressing the lack of data availability, coupled with promoting better household compliance with waste management practices, are critical to achieving sustainable environmental and health-based objectives.

The study also stresses that local communities and stakeholders should be part of the process for long-term greenhouse gas emissions sustainable. Although CBO and NGO are very important in collecting waste, a more systematic mechanism that includes private sector in self-sustaining waste management service development through public private partnership will ensure availability, accessibility and efficiency of waste management services. Furthermore, enhancing institutional frameworks and having some clear rules on segregation and disposal of waste may help household and enterprises in complying better. A one size fits all solution that combines community involvement, tech based waste disposal technology, backed by sustainable policy adoption is the need of the hour to rebuild Khulna into a sustainable and habitable community. This inclusion of such integrated strategies will help the city solve its waste management problem as well as mitigate climate change by reducing greenhouse gas emissions and conserving natural resources.

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REFERENCES

1. Noman, A. A., Rafizul, I. M., Moniruzzaman, S. M., Kraft, E., & Berner, S. (2023). Assessment of municipal solid waste from households in Khulna city of Bangladesh. *Heliyon*, *9*(12).

2. Ahsan, A., Alamgir, M., Imteaz, M., Shams, S., Rowshon, M. K., Aziz, M. G., & Idrus, S. (2015). Municipal solid waste generation, composition and management: Issues and challenges. A case study. *Environment Protection Engineering*, *41*(3).

3. Islam, M. S., & Moniruzzaman, S. M. (2019). Simulation of sustainable solid waste management system in Khulna city. *Sustainable Environment Research*, *29*(1), 14.

4. Letshwenyo, M. W., & Kgetseyamore, D. (2020). Generation and composition of municipal solid waste: case study, extension 7, Palapye, Botswana. *SN Applied Sciences*, *2*, 1-8.

5. Noufal, M., Yuanyuan, L., Maalla, Z., & Adipah, S. (2020). Determinants of household solid waste generation and composition in Homs City, Syria. *Journal of environmental and public health*, *2020*(1), 7460356.

6. Sivakumar, K., & Sugirtharan, M. (2010). Impact of family income and size on per capita solid waste generation: A case study in Manmunai North Divisional Secretariat Division of Batticaloa.

7. Noufal, M., Yuanyuan, L., Maalla, Z., & Adipah, S. (2020). Determinants of household solid waste generation and composition in Homs City, Syria. *Journal of environmental and public health*, *2020*(1), 7460356.