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URBANIZATION CHALLENGE: SOLID WASTE MANAGEMENT IN SYLHET CITY, BANGLADESH

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Abstract— In the rush towards urbanization as well as with emerging consumption, many developing countries have witnessed the overflow of waste and depletion of the inexhaustible natural resources at an alarming rate. As wastes are the outgrowth of the urban system, the urban dynamics influence the quantity, types and management of waste. The purpose of this study is to estimate the amount of the generated wastes from 2002 to 2017 with the urban growth of Sylhet city and implement the 3R (recycling, reuse, refuse) strategy conceptually for maximizing resource recovery and reducing landfilling. In this study, solid waste generation and its composition is estimated by collecting data through interviews encompassing 300 units from the representative areas and direct field survey. Correlation test between population and solid waste has been performed to measure the strength of association. The result indicated that, in 15 years, waste generation has increased 170 tons which calls for better management. From the study it is shown that about 72.46% (188.396 tons) of the waste can be minimized by executing 3Rs leaving only 27.54% to be dumped into landfill. It is evident that, implementation of the 3Rs will have a profound impact to protect the environment.

Keywords—Correlation, Pollution, Solid Waste, Urbanization, 3Rs (recycling, reuse, refuse)

I. INTRODUCTION

“Waste is the evidence that we are doing something wrong. Landfills simply bury the evidence and incinerators (by whatever fancy name they are called) simply burn the evidence” [1]

Though urbanization is inevitable for the development of our country, the rapid urban growth has dispensed heavy pressures on land and resources and resulted in serious environmental problems. Urbanization is influenced by the aptitude that cities and towns have better economic, social and political

advantages than the rural areas. With the prompt increase in population and unplanned urbanization, many developing countries including Bangladesh, are facing a colossal challenge of managing municipal solid waste [2]. Both the rise in population and increase in per capita waste generation, have reflected that, by 2025 this amount will reach almost 47,000 tons/day and nearly 17.2 million tons per year [3]. Disposal in landfills is still the most common destination, but shortage of land for landfills is a physical constraint. Moreover, urban development is replacing undeveloped land causing the bare lands to be filled up leaving no suitable space for using as landfills. Migration from the stagnant and low paying rural areas to the more paying urban area for better lifestyle has incited the increase in types and amount of solid wastes in and around Sylhet city. Again, improper solid waste management (SWM) is one of the most burning environmental problems in Bangladesh, hence solid waste disposal is a challenging issue for a fast-growing city like Sylhet [4]. Again the illegally dumped uncollected waste in open spaces, water bodies or even burnt on the street and roadsides, ascending serious threat to environment [5].

Sylhet city corporation (SCC) is becoming a concrete jungle and fading its greenery day by day due to the unplanned and improper urbanization with increasing waste stream. Being not an industrial city, most of the generated wastes here are of domestic, commercial and clinical type and these are increasing with the growth of urban system. Again, a total number of nine natural drainage channels (locally called Chara) [6] are being filled up by the wastes from most of the households (situated along or near the Chara) as well as the street sweeping, which eventually affects the natural drainage system and the environment. Also, at Lalmatia, a low-lying land in Mogla bazar, wastes are disposed in an uncontrolled manner causing blockage of drains resulting in localized flooding and unhygienic condition. Here, SCC is the only responsible organization for the management of solid waste though some community-based organizations (CBOs), Non-



Governmental Organizations (NGOs) and private sectors are also working. Though SCC has taken initiatives to manage solid wastes by collecting, transporting and disposing, these practices are being challenged due to the uncontrolled collection system, inadequate space and increasing value of land. In the existing Solid Waste Management (SWM) system undertaken by SCC, some notified problems are:

- ✓ Inadequate service coverage,
- ✓ Operational inefficiencies of services,
- ✓ Improper management of clinical (hazardous) waste.

Again, the Lalmatia landfill is going to be completely filled up requiring the selection of new landfill sites. But new landfill site acquisition is so uncertain due to the NIMBY (not in my back yard), BANANA (build absolutely nothing anywhere near anything), LULU (locally unacceptable land use) and NOTE (not over there either) syndrome [7] in the local community. The increasing rate of solid waste has a hostile effect on the environment as well as social and professional life of the city dweller and urban planners. Treating waste as a resource is the first step towards waste management and conserving resources [8]. Therefore, an approach to implementation of 3Rs (recycling, reuse, refuse) will have an inferential efficiency in managing and lessening the waste hazard. So, this study intends to develop the concept of 3Rs order to solve the existing problems of solid waste management in Sylhet city like requirement of sites for landfill, overburden of increased amount of solid waste, cost of management, health and hygiene and finally detrimental environmental and sanitary conditions. In addition, it will also help to solve the unemployment problem by involving the poor people in resource recovery operations.

A. Background Study

This study aims at assessing the correlation between population, urban growth and solid waste in Sylhet city and recommending proper approach to minimize the waste stream. Recently, a lot of studies have been conducted on these issues. A little of the studies are emphasized in table 1.

Table 1. Summary of the literature reviewed for this study.

Study on correlation of urbanization with population and solid waste			
Year	Study	Reference	Focus
1999	Concluded that the increasing population leads to swelling the waste generation, again built up environment arrangement influences the waste management.	[9]	Correlating population and built up environment with solid waste
2001	Explored the dynamic interrelation between the urban system and the waste management	[10]	Urban system and waste management

	system.		
2007	Studied on correlation between various type of population related variables and waste related variables.	[11]	Population and waste
2011	Identified the inappropriate solid waste disposal system as a major environmental problems due to rapidly increased population and unplanned urbanization in Sylhet.	[12]	Population, urbanization, solid waste generation
2012	Worked on the urbanization induced solid waste management in India to see the upcoming trends of urbanization and accordingly generation of waste.	[13]	Urbanization, waste generation
2014	Studied to examine the aftereffect of unplanned urbanization on environment in Sylhet City Corporation (SCC).	[14]	Urbanization and environmental problems
2015	Investigated the solid waste management in the Bolgatanga municipality of the upper East region, Ghana to show that the increasing urban population had a negative impact on waste management.	[15]	Population and waste generation
2016	Studied to understand how the residential land use and associated activities in a small/medium scale urban area are related to the quantity of generated waste, in South India (three cities- Thiruvananthapuram, Coimbatore and Kozhikode).	[16]	Land use based modelling of solid waste generation
Study on solid waste management and options outside Bangladesh			
2003	Pointed composting as a feasible pretreatment process of solid waste before going to the	[17]	Solid waste management, Recycling (composting)



	disposal site.		
2006	Studied the problems, issues and challenges regarding the municipal solid waste management was studied in the Southern Province of Sri Lanka.	[18]	Solid waste management, Resource recovery
2006	Made general overview of current solid waste management practices in Çorlu Town of Turkey.	[19]	Solid waste management, recycling
2007	Attempted to give a picture of the ongoing 3R implementation in urban municipal solid waste management in Asian countries.	[7]	Solid waste management, 3Rs
2009	Studied on the municipal solid waste management in Kolkata (India) and reported the availability of different recyclable items at the Dhapa dumping ground, with corresponding market prices.	[20]	Solid waste management, Recycling
2009	Identified that recycling is one form of sustainable solid waste management.	[21]	Solid waste management, Recycling
2009	Conducted a research to find out the evolution of solid waste management in Malaysia.	[22]	Solid waste management, Recycling
2009	Aimed at evaluating the generation, characteristics, and management of solid waste in Malaysia.	[23]	Solid waste management, 3Rs
2010	Conducted a study in Prince George campus of the University of Northern British Columbia (UNBC) and observed the three most significant material types for targeted waste reduction and recycling efforts.	[24]	Solid waste management, reduction and recycling
2011	Studied to compare the current situation, historical background, and effectiveness of 3R	[25]	Solid waste management, 3Rs

	policies within one region [the European Union (EU)] and five countries (USA, Korea, Japan, China, and Vietnam.		
2012	Aimed at making people aware of the 3Rs culture, in particular, university students (International Islamic University Malaysia).	[26]	Solid waste management, 3Rs
2015	Worked to assess the municipal solid waste management in relation to 3Rs strategy in Wa, Ghana.	[27]	Solid waste management, 3Rs
2017	Carried out the characterization and the trend of solid waste generated in University of Lagos, Nigeria and revealed that, recyclable potential of the waste is very high (75% of the total waste generated) in the University campus.	[28]	Waste management option, recycling.
2017	Studied on the waste disposal practices by residents of various types of dwellings in Dharwad city (Karnataka, southern India).	[29]	Solid waste management, 3Rs
2017	Evaluated the sustainability and effectiveness of the municipal solid waste management system in Bangkok.	[30]	Solid waste management, 3Rs
Study on solid waste management and options outside Bangladesh			
2009	A thesis work was conducted on recommending the usage of Rs to minimize the solid waste taking in consideration the entire country of Bangladesh.	[31]	Solid waste management, Rs
2012	Investigated the current disposal system of clinical waste and also the waste management system of Sylhet City Corporation (SCC).	[32]	Solid waste management, recycling

2013	Detailed the technical and methodical issues of solid waste management as well as the non-technical and specific management of solid waste.	[33]	Solid waste management, Rs
2013	Reviewed the amount of recovery and recycling of wastes in Chittagong city and recommended for promoting 3R strategy in waste minimization.	[34]	Solid waste management, 3Rs
2013	Explored people's perception on adopting 3Rs concept for Solid Waste Management (SWM) in Chittagong, Bangladesh.	[35]	Solid waste management, 3Rs
2014	Emphasized that 3Rs approach can promote the efficient use of resources, harmonizing both environmental and economic concerns through making efforts on waste reduction, reuse and recycling in Bangladesh.	[36]	Solid waste management, 3Rs
2014	Developed the 3R strategy for waste management in the urban areas of Bangladesh.	[37]	Solid waste management, 3Rs
2016	Studied solid waste management in Dhaka city and stated that, recycling can solve the unemployment problem as well as offering an admirable environment.	[38]	Solid waste management, recycling
2017	Revised the solid waste management Practice in Dhaka City and emphasized on resource recovery.	[39]	Solid waste management, resource recovery
2017	Conducted a research work on municipal solid waste management bin Sylhet city, Bangladesh and showed the negative impact of poor solid waste management in SCC.	[40]	Solid waste management, 3Rs

2018	Reviewed the solid waste management process and impacts on the environment and living species due to solid waste in Sylhet City Corporation, Bangladesh.	[41]	Solid waste management
2018	Studied the challenges of solid waste management in Sylhet City Corporation.	[42]	Solid waste management

II. STUDY AREA

The study area for this research is Sylhet City Corporation (SCC) which is situated in the Sylhet Division, Bangladesh. SCC consists of 27 wards and 210 mahallas, and has a total area of 26.50 km². In this study, 16 wards were taken as representative as shown in Fig. 1. These wards were selected according to their land use pattern, population, household and area. A brief description of these wards is given in the table 2.

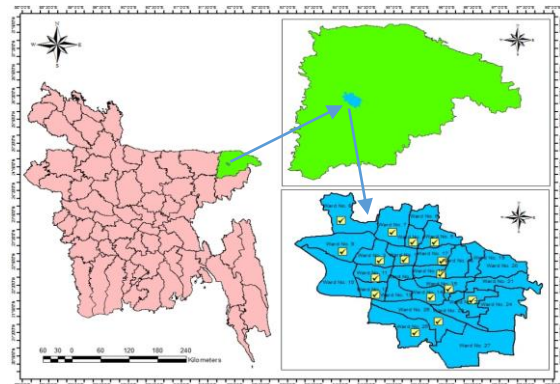


Fig. 1: Map showing the study area.

III. METHODOLOGY

Data were collected in order to estimate the waste generation rate and to examine the composition of the generated wastes. Also, correlation analysis between population and solid waste has been performed after collecting data. Finally wastes have been sorted to determine the percentages that can be managed by implementing the 3Rs (Reduce, Reuse, Recycle). By the time, the existing management system of solid waste and practice of using Rs have also been assessed to meet the aim of this study by recording the views of the respondents. Then data have been analyzed and findings have been made.

Table 2: Description of the selected wards

Ward selected	Population*	Household	Land use type
Ward 1	11781	2143	Mostly residential



Ward 3	15229	2800	Residential and clinical
Ward 4	10919	2269	Residential and commercial
Ward 5	21982	4206	Residential
Ward 7	29726	5906	Residential
Ward 8	28194	6069	Residential
Ward 9	27475	5159	Residential, commercial and institutional
Ward 11	18668	3752	Residential, commercial and clinical
Ward 12	14184	2656	Residential
Ward 14	17044	3679	Commercial, residential.
Ward 15	19076	3826	Commercial, residential
Ward 16	14845	3554	Residential
Ward 17	19506	3939	Residential and commercial
Ward 22	15799	3231	Residential, institutional
Ward 25	15106	2864	Commercial and residential
Ward 26	19997	3831	Commercial and residential

*Population and household data (census 2011)

A. Data Collection

A semi-structured questionnaire with open-ended and close-ended questions has been designed, pre-tested and modified to the final shape for data collection.

A (a). Primary Data Collection

This includes pilot study and field study. In pilot study, the wards from which data would be collected and the sampling size have been reviewed and field study has been conducted in those selected area.

➤ Pilot Study

For this study, the desired sample size was estimated by using the statistical formula for sample size determination by M.Nurul Islam [43]. Using a margin of error of 0.06 with a 95% confidence level and sample frame of about 60,000 households (in SCC), 300 units (including households, institutions, hospitals, restaurants, shops etc.) were estimated as the sample size for the socio-economic survey.

➤ Field Study

The field study, was conducted, using stratified random sampling method representing the 16 wards selected in the pilot study and 300 households with a total population of 1476. Some household data were collected in March 2017 and the rest were collected between October 2017 to November

2017. Survey by questionnaire was conducted to collect required data. Also, formal and informal interviews were taken along with identification of problems, efficiency and limitation of the existing management system.

A (b). Secondary Data Collection

Secondary data have been collected from SCC conservancy wings, related NGOs and published papers.

B. Data Analysis and Waste Generation Rate

From 16 wards 300 households were taken as sample consisting a population of 1476. The collected data has been overviewed to estimate the waste generation rate.

C. Correlation Test and Trend Analysis

The correlation test was made out in order to determine the association between population and solid waste. The Pearson correlation coefficient (PCC) (also referred to as Pearson's r or the bivariate correlation) has been calculated which is a measure of linear correlation between the variables.

D. Examination of Waste Composition

To review the composition of waste, 3 representative samples of 100 kg waste from 3 different waste collection trucks were taken to examine the waste composition. The average weight of the waste content was estimated.

E. Waste Sorting According to 3Rs

3 representative samples of 100 kg waste were then classified according to the contents. Then each type of materials in the waste content was weighed to determine the type of R(s) that can be implemented to manage the waste. Also, the percentage of waste can (could) be processed through Rs has been determined.

IV. RESULT AND DISCUSSION

A. Existing System of Solid Waste Management

According to SCC, each of the 27 words has 2 collection vans to collect solid waste from door to door. Also, some CBOs have their own collection vans. All these vans collect waste from their assigned area and take them to the secondary transfer station (STS). The waste collection rate is 66.47% as per investigation in 300 households, leaving 33.53% waste uncollected. There are 4 STSs in Sylhet City Corporation described in table 3. SCC requires no land to attune the STSs, as these are located on Government owned land.

Table 3: Location of the Secondary Transport Stations (STSs)

STS no.	Location of STS	Ward no.
1	Swarnashikha Road, Kadamtoli, Mouza Mominkhola.	Ward-26
2	Mouza Municipality, Opposite to Mita Community Center, near Allahu roundabout, beside Shahi Idgah.	Ward-17
3	Rikabi Bazaar near Police Line, Mouza Municipality.	Ward-1
4	Near Shahid Smriti tower of MC College, Mouza Raynagar.	Ward-20

In STS, primary waste collection vans are emptied into containers, settled in pit(s) by gravity. An electric hoist is then used to transfer the waste into large capacity trucks provided by SCC and directly taken to Lalmatia landfill without any segregation. The overall management system undertaken by SCC is shown in Fig. 2.



Fig. 2: Existing waste management system in SCC

B. Current Practice of Waste Segregation

It is found from the field investigation of 300 units (households, institutions, hospitals, restaurants, shops etc.) that in 204 units (about 68%), source separation of some kinds of waste like paper and paper products, plastic bottles, broken glasses, rubbers and tires, E-wastes, metals etc. is being practiced. Other 96 units do not practise waste sorting and it is also to be mentioned that lower income families have less things to be separated than the higher income families.

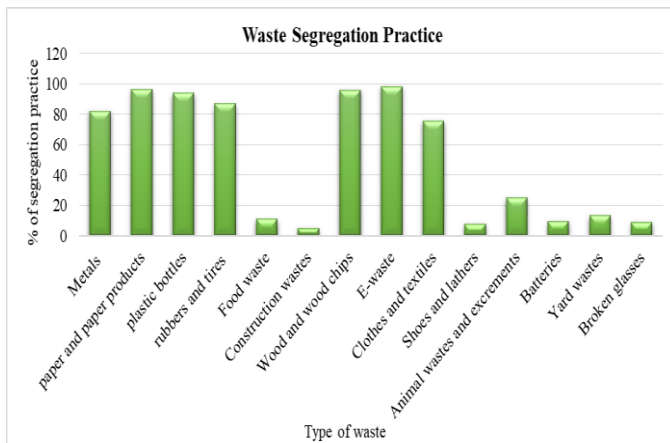


Fig. 3: Fraction of the type of waste segregated locally.

It is one of the notable findings that, people seems to separate their waste less than previous time due to the lack of space as vacant spaces are being filled up. Again, the practising 232 units separate different types of waste in different fraction as shown in Fig. 3.

C. Standing Landfill Condition

The one and only landfill site used by the SCC is situated in Lalmatia, Mogla bazar, Sylhet. Lalmatia site is about 1-15 ft.

below the existing road level, fully marshy and located about 5 Km away from the city center. Here, some of the scavengers stealthily collect some types of waste and sell those to make their livelihood. But this kind of waste sorting is not allowed by the authority. A noticeable thing is that in the landfill, wastes are openly burnt (as shown in Fig. 4) either partially or completely to reduce the volume which is very detrimental to the environment.



Fig. 4: Burning of waste in landfill

It is worth mentioning that, there is a separate space in Lalmatia landfill for the dumping of medical waste and some of the wastes are segregated by the workers (figure 5).



Fig. 5: Segregation of medical waste near the landfill

D. Waste Generation Rate

Being not an industrial city, most of the generated wastes in Sylhet are of domestic, commercial and clinical types. Daily generated waste of 300 units including households, institutions, hospitals, restaurants, shops etc. was measured and in total it was found 706 kg against 1476 people. On an average, it becomes 0.48 kg/cap/day including all types of wastes.

E. Correlation Test

To measure the strength of association in between the variables (population and solid waste) correlation test has been worked out and Pearson Correlation Coefficient (PCC) has been determined. The result have revealed that, there is high and strong association between the variables as the value of PCC is near about 1. Table 4 shows the numerical value of the variables. In this test, pairs of variables (n) = 4 in each computation. The solid waste amount used in this analysis is the collected waste by the Sylhet City Corporation. Due to the unavailability of generated data, total generated amount of solid waste has not been taken in this analysis.

Table 4: Variables to be correlated

Year	Population*	Solid waste (tons)
2002	299679	90
2007	427265	120
2012	552828	200
2017	782646	260

Correlation test (Pearson Correlation Coefficient) =0.982*
 (*Correlation is significant at the 0.05 level).

F. Trend Analysis

In the last 15 years, solid waste has increased along with the increase in population as shown in table. From 2002 to 2017, population in SCC has increased from 299679 to 782646 i.e. 482967. Again the solid waste collection by SCC is 260 tons in 2017 which was 90 tons in 2002. The trend in population and solid waste is shown in Fig. 6.

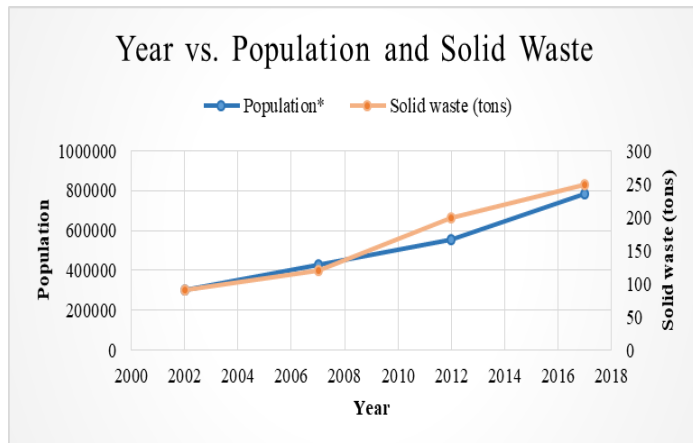


Fig. 6: Trend in population and solid waste with time

G. Composition of Waste

To determine the waste composition, 100 kg sample was taken 3 times from 3 trucks of wastes and the waste contents were classified according to their category. The percentages of the generated waste with the composition are shown in Fig. 7.

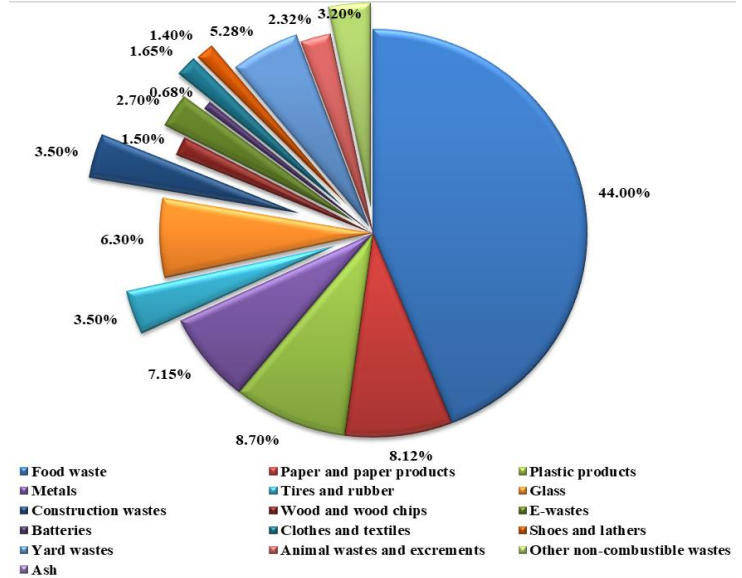


Fig. 7: Waste composition in 100 kg sample.

H. Waste Minimization Rate through 3Rs

In the existing management system undertaken by the SCC, there is no systematic use of 3Rs (Reduce, Reuse and Recycle). In fact, there is hardly any initiative to adopt the concept of 3Rs. But it is evident that, if this situation is continued, within a few years, a new landfill site will be required which is very difficult to find due to the increasing cost of land and public views towards the landfill. Though local hawkers collect wastes (paper, plastic, metal etc.) from door to door which is re-processed to be sold, this percentage is not significant enough. In accordance with the finding, about 72.46% of 260 tons of waste can be minimized by implementing 3Rs. As a result, each day only 27.54% i.e. 71.604 tons of wastes will need to be dumped in the landfill which will be very effective to meet the challenge of managing solid waste. Again, it has been estimated that, of the total manageable wastes (188.396 tons), 23.81% can be reduced, 15.87% can be reused and 60.32% can be recycled. The study was conducted in dry season and so the results are more valid for dry season.

V. CONCLUSION

The study was conducted in Sylhet city with a view to detecting the solid waste management practice and making decision on solid waste management. The study reports that Sylhet City Corporation (SCC) is losing its green cover remarkably and facing a massive urban growth. Furthermore, the study has estimated the waste generation rate in SCC as 0.48 kg/cap/day which is approximately 376 tons per day. As waste is increasing with urban growth and it is not possible to stop urbanization, we cannot but reduce the amount of waste generation. Hence, the composition of waste as ordained calls up for source segregation and resource recovery. In fact, the



promotion of the 3R (Reduce, Reuse, Recycle) strategy is a panacea to achieve proper solid waste management in Sylhet City Corporation. The study reveals that executing the 3Rs with proper technology available, 72.46% of the generated waste can be minimized i.e. only 27.54% of waste is to be dumped. As a result, demand of land for waste disposal will be curtailed, environment will be availed and revenue will be added from waste recycling and resource recovery sector.

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