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STUDY ON THE RELATION BETWEEN SOLID WASTE VOLUME AND RESIDENTIAL COLLECTION METHODS WITH REFERENCE TO SOYSAPURA FLATS

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Abstract

Everyday human generates waste and municipal solid waste is supposed to be increased with urbanization. 3 billion urban residents generate 1.2 Kg of waste per person per day. This study was carried in Soysapura Flats which is located 17 Km away from the financial capital of Sri Lanka. The main objective was to study the impact of the volume of urban domestic solid waste on collection and storing methods in Soysapura Flats. The literature reveals that the volume of waste generated in developing countries continues to increase and the contribution by the urban domestic waste is effective but there is a lacuna of studies related to the residential waste collection and storing in the aspect of volume. The study used a combination of both quantitative and qualitative methodologies. 80 families were selected and interviewed to identify their methods of waste disposal, devices, practices and attitudes. And necessary measuring tools were used in order to carry out the volume measurements. The findings revealed that 8.062 litres of degradable waste and 5.828 litres of non-degradable waste generated per day by a family of Soysapura Flats. The degradable volume of waste was easily managed with the present collection method and system but not the non-degradable waste category. Further detailed investigation is needed to identify the impact of waste volume on collection methods, especially in the aspect of waste and waste types.

Keywords: *Urban solid waste; Residential collection methods; Impact of waste; Waste volume.*

1. Introduction

Solid waste has become a major issue for the world as well as Sri Lanka. Day by day its severity increases due to several key factors such as population growth, rapid urbanization, hazardous wastes, drawbacks of state waste management strategies and attitude of people. The waste management can be clearly stratified into several layers as waste generation, classification, collection, transportation, disposal and treatment (Williams, 2005). This study was concentrated on the aspect of the collection and storing of waste at the place of generation.

Waste collection and storing at the source of generation can be considered as the immediate steps after the waste generation. The importance of the waste storage at the source must be well identified. According to United Nations Environment Programme (2005), Storage and collection can be considered as important scales in understanding successful or unsuccessful solid waste management systems.

In Sri Lanka, there is a clear chain of waste transfer from waste generation to open dumping. Most of the approaches and solutions were given on the final levels (level of dumping and landfilling) of this chain. The initial level of the chain is the waste generation where the issue can consider to be simple in handling due to some points such as less contamination and attitude of people.

According to Ilango (2004), countries with low and middle income are more vulnerable with the issues regarding solid waste. Highlighting factor was the amount of money which was spending over solid waste management. The present world monetary allocation for waste management is \$205.4 billion and it will be increased to \$375.5 billion in 2025 (Hoornweg & Bhada-Tata, 2015). Most of the amount of money was spend for waste collection and transportation by Municipal Councils (MC) around the world but not for the disposal and treatment methods (Bandara & Hettiaratchi, 2010).

Every fact proves that the attention must be drawn towards the correct process of handling the waste at the level of waste generation. Therefore a clear identification of some factors are very much important. This study was intended to investigate the impact generated by the volume at the level of waste collection in urban domestic context, as it is appeared to be one of the most crucial parameters in studying and analysing waste.

2. Background

2.1. SRI LANKA

Sri Lanka is a tropical island located in the Indian Ocean with a total land area of 65,610 km². The total population is 20.38 million people (Ministry of Policy Planning and Economic Affairs Sri Lanka, 2015). According to Vidanaarachchi, Yuen, & S.Pilapitiya (2006), the urban population in Sri Lanka is 22%. The country has 9 major provinces and 25 districts. Western province is the highest contributor for the country's overall waste generation. With the population increase, the waste has become a huge issue for the Sri Lankan context.

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According Wijerathne, et al (2012) open dumping has become the solution to the present waste in Sri Lanka while most of the local authorities are still continuing it without delivering sustainable solutions

2.2. SOYSAPURA HOUSING SCHEME

It is Located 17Km away from the financial capital of Sri Lanka and Belongs to western province and Colombo district. The housing scheme was established before 1994 and it is considered as a low raised housing scheme. The Soysapura housing scheme is under the control of Moratuwa MC.

- Total buildings- 103
- Total houses- 1912
- Gramasewa divisions-2 (548B Soysapura South and 548A Soysapura North)
- Population-

548B Soysapura South	-2710
548A Soysapura North	-2841
Total	-5551
- Average family members per house -2.9

103 buildings are spread in an area of 44.91 acres. The internal roads interconnect the buildings and used in the waste collection by the vehicles of Moratuwa MC.

The single building unit was built with chutes; a mechanism for collecting waste, see Figure 1. But the system of chutes failed with the passage of time due to issues regarding classification of waste, type of waste and the collection rate of waste. Later these chutes were sealed and the waste was collected inside the house using other methods.

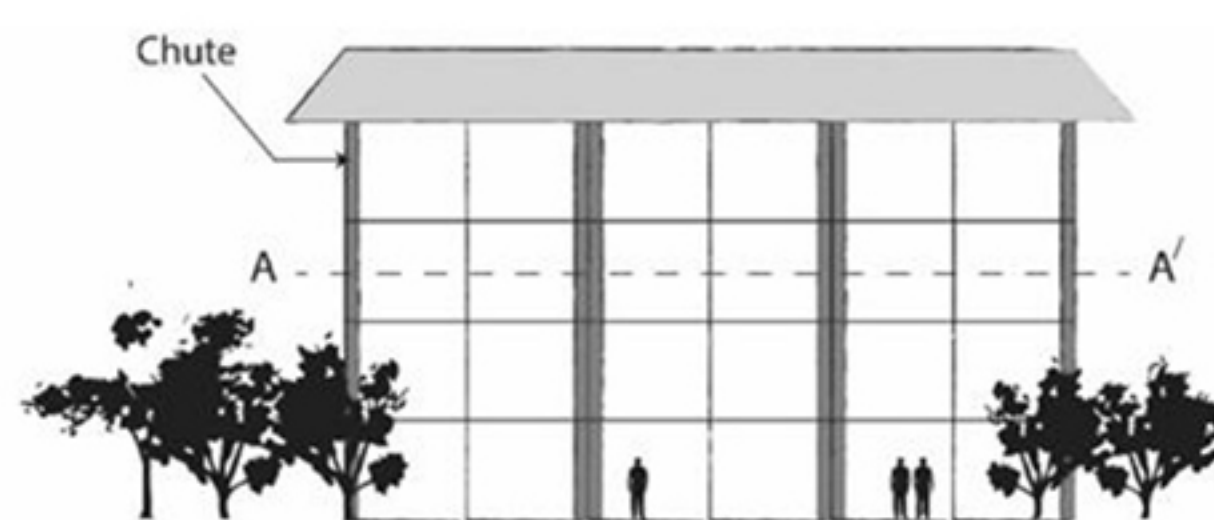


Figure 1, Placement of chutes in a single building unit

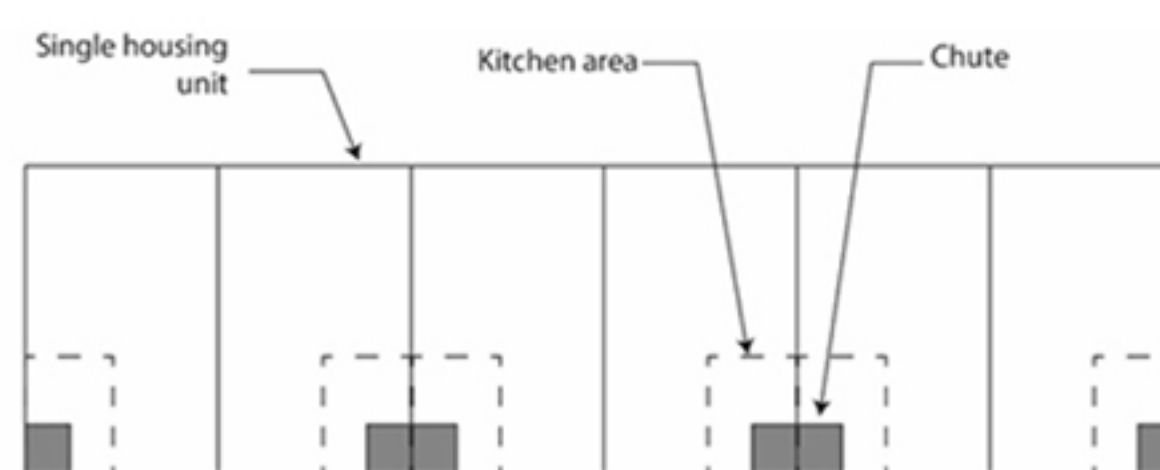


Figure 2, Cross section A-A/

There is a common house plan for the Soysapura housing scheme. Main components of a single house is Living room, Kitchen, 2 rooms and a Bathroom.

The space is somewhat restricted within the house. The furniture, electronic appliances and utensils were placed within this restricted space.

Waste generated by the Soysapura flats were highlighting the qualities of urban domestic waste. Basically, the Moratuwa MC collects waste under two categories as degradable and non-degradable. The most common terms used by the house owners are "*Indul*" (degradable waste) and "*Nodirana kunu*" (non-degradable waste). "*Nodirana kunu*" will be collected by the MC on every Wednesday and Sunday, "*Indul*" will be collected daily except Wednesdays and Sundays.

3. Methods and methodology

The Soysapura housing scheme is one of the oldest and most populated urban settings in the western province of Sri Lanka. It is a place where no modern waste collecting system is practiced. Most of the house dwellers are under middle class-income. The flats were located in a large horizontal area. And it can be considered as a small township.

The sample was 80 families randomly selected from Soysapura flats. Face to face Interviews were conducted among families using structured questionnaires. All the 80 families were used in measuring the degradable waste volume while taking their volumetric measurements, 10 families were monitored in measuring non degradable waste volume due to limitations. Waste was considered as the unit of analysis. The necessary measuring tools were developed in order to carry out the volume measurements.

4. Results and discussions

Several collecting and storing methods were practiced by the house owners and their satisfaction level was identified by the questionnaire survey. 85% were satisfied with the present waste management process by the MC and 15% of them were not.

As a result of the questionnaire survey, 72% of the families were using the kitchen area as the place to keep their waste collections, while 20% using an outside place of the house, 4% living room, 3% bathroom and 1% a room. According to observations, kitchen was used due to easiness in handling waste, ability to reach, the ability of placing, attitude about waste and usage. Through

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these points, a clear link between the spatial arrangement of the kitchens and the garbage collecting and storing devices were clearly highlighted in the Soysapura housing scheme.

Most house owners tried to restrict their waste collection method into several areas inside the kitchen, Figure 4 depicts the current situation. Most of them were choosing the nearest and most easily reachable place to the sink in placing their degradable waste bucket.

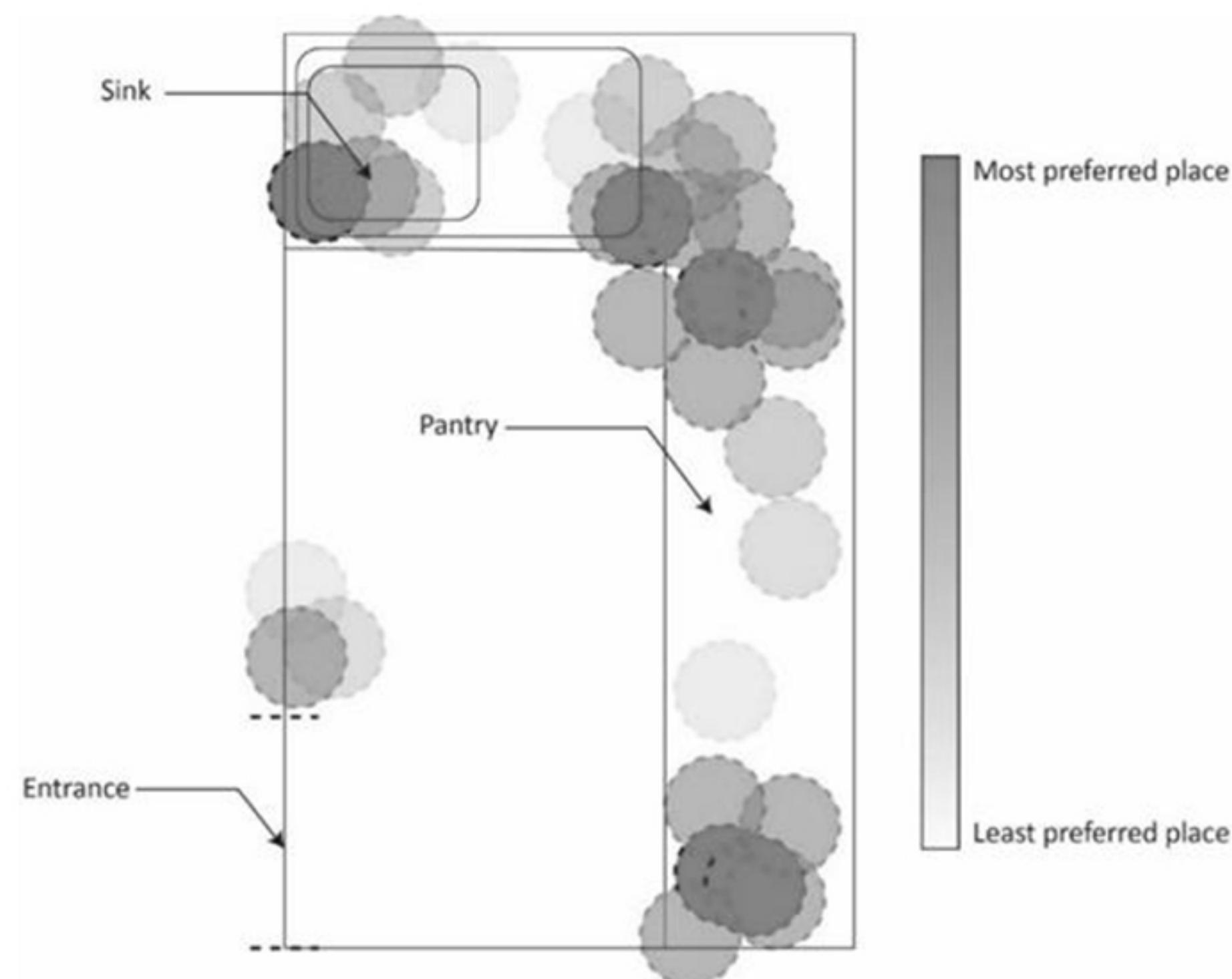


Figure 4, Placement of waste bins in the kitchen

Most of the house owners place their non-degradable waste collecting device near the degradable waste collecting device. Indirectly they have tried to make a single collection place for both of the waste types.

A plastic bucket was distributed by the Moratuwa MC among the house owners with the intention of collecting and storing short term degradable waste (*"Indul"*). It must be used by every house owner and the MC will reject to collect the waste if the classification was not done under the correct process.

Main parts of this bucket were the Lid, Handle and Body. The overall volume of the bucket was 18 litres.

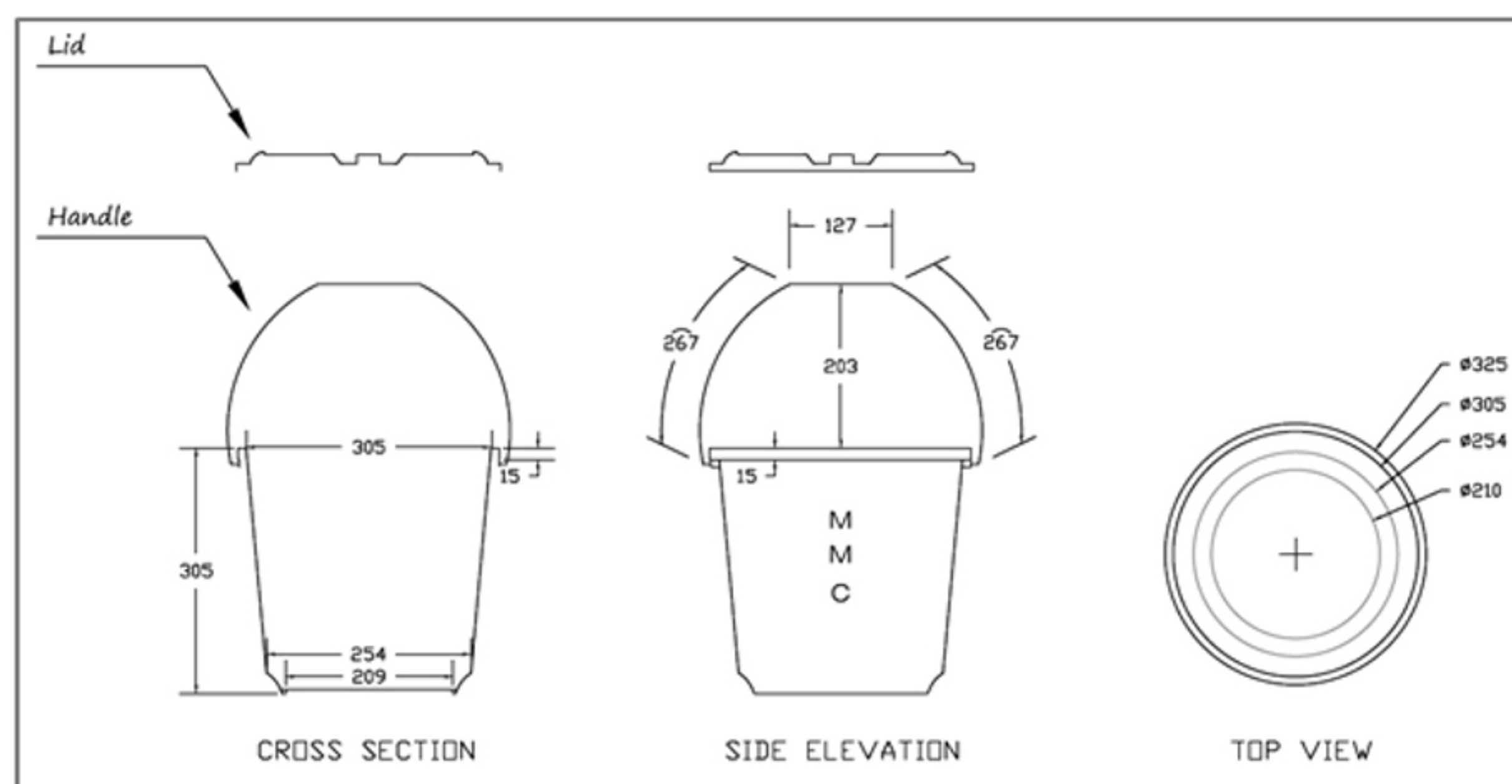


Figure 5, Measurements of the “Green colour bucket” (All the measurements are in mm and scale is 1:1)

In many instances the height, opening and base of the “green colour bucket” have become favourable factors in handling degradable waste in Soysapura housing scheme. For example, the bucket height of 1ft has made a link with spatial arrangement of kitchen and the human body measurements.

The degradable waste volume generated in the houses can be easily handled by the opening of the bucket which has an area of 706.85cm². The form of dishes and the type of degradable waste were some directly responsible reasons, for example, rice, curries, vegetable and fruit scraps, most of them have the ability of using the maximum volume of the given bucket, but there are exceptional situations like rotten and uncooked green leaves, banana leaves, coconut shells, “rambutan” peelings in the bucket.

The other most effective part of the bucket was considered to be the lid. As there are favourable climatic conditions for many insects and rodents the lid plays a major role in protecting and enclosing the waste. And it is a point of cleanliness. Finally, 79% of the house owners were satisfied with the “green colour bucket” and its function while 21% were not.

There is a clear link between the satisfactory level of waste management by the MC and the satisfaction about the green colour bucket and its function. 85% and 79% of people have said yes respectively for above questions. Similarly, above link is highlighting the relation between the waste collecting bucket and the collection rate of MC. But if the MC stops daily collection the result may

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change in a completely opposite manner. In each of the above steps, the volume of waste plays a major role.

Plastic buckets with various sizes were used to store non-degradable waste. Their volumes and process of the usages were highly varying. Most of the families who were less than 3 members have been using a dustbin or a plastic bin to collect their non-degradable waste. Most of them were practiced to a pattern of waste generation in which they could predict the volume of the waste generation per week.

22 families were using open containers. These open containers have become a smart solution in storing excess volumes of waste. 4 families were using the buckets with lids and they were using the lid as a tool in compressing the waste. But the negative fact was that the users were unable to keep several buckets due to the issues regarding space.

54% of the house owners preferred to use polythene bags to store and collect waste due to its collection rate, space consumption and easiness in handling. Most of the house owners were able to manipulate the waste volume using polythene bags to store waste. Here they were unable to reduce the volume of waste but they were able to increase the number of collecting devices (the polythene bags). In the other hand, 15% used garbage bags, 15% used dustbins, 11% used paint buckets and 5% used corrugated and cardboard boxes in collecting and storing their waste.

But the issues were aroused when the number of overall volume of polyethylene bags which were used to collect waste, increase when compared with the space allocated in the house.

There were clear links between collection methods of non-degradable waste and the family members of the house, for example, 32 of the families who were using polythene bags to collect the waste consisted more than three members. Special point was that those families were with small children who were under the age 6 and their waste generation was high. And most of them were unable to predict the waste that could be generated in the upcoming week.

4.1. DEGRADABLE WASTE VOLUME

The common “green colour bucket” was used as the vessel to collect and measure the degradable waste. As the initial step, the exact volume of the vessel was calculated. It was 18 litres. A specially made ruler was used in measuring the height of the garbage level in the bucket. The ruler was

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calibrated at every 2-liter mark to take the approximate height of the waste level and to reduce the fractional error. The measurements were recorded.

Table 1, Result generated using 80 families.

Overall degradable waste volume generated by 80 families per day	645 litres
Average volume of degradable waste generated by a family per day	8.062 litres

4.2. NON-DEGRADABLE WASTE VOLUME

Huge variation of types of wastes, collecting devices, family types and private issues were limitations for the calculation of the volume. Therefore a method was developed. A vessel was used with known measurements (50 litres). The questionnaires and observations were used to collect the information and to have an idea on approximate quantity and types of wastes generated in the Soysapura housing scheme. After the questions were raised, the volume of the vessel was approximately predicted to suit the one-week non-degradable waste volume. A level indicator was attached to the wall of the vessel to take the waste volume measurement. The indicator ruler was calibrated at every 2-litre level. A disk was used to take the correct level of waste.

Finally, 10 families were selected from the Soysapura housing scheme, 5 of them were nuclear families and others were extended families. They were given the vessels to dispose of waste. They were given full freedom without interfering their normal disposing behaviour. After a week the volume measurements were recorded.

Table 2, Result generated using 10 families.

Average volume of the waste disposed by 5 nuclear families per week	33.6 litres
Average volume of the waste disposed by 5 extended families per week	48 litres
Overall volume of waste disposed by 10 families per week	408 litres
Average volume of waste disposed by a family per week	40.8 litres
Average volume of waste disposed by a family per day	5.828 litres

The volume of waste disposed of by the extended families was visibly higher than that of the nuclear families. The huge variety of the waste was a special factor in the collected waste. 3 of above 10 families were concerned about the

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volume of the given bucket. And they have managed the bucket volume by stacking and crushing of waste.

Free voiding space between waste objects was very high. And some types of wastes such as Styrofoam boxes, salmon tins, water bottles, soft drink bottles, coconut shells and polythene were directly affecting to the waste volume calculations. Special categories of waste such as napkins, sanitary pads and medical waste were there in the buckets and the contribution to the volume of waste was considerable.

The degradable volume of waste is most probably constant in its value but the field observations proved that the non-degradable volume of waste was not constant due to several reasons such as consumer attitudes, market behaviour, advertisements, product variations and marketing trends. For example, most of the degradable waste bins were with food wastes and it is occurring in the same pattern but the non-degradable waste bins were filled with different types of wastes and above mentioned reasons directly control the volume of the generating waste.

The discussions and interviews proved that the waste volumes were changing with the month of the year. For example, in the month of April, the both volumes of degradable and non-degradable wastes are rising in an enormous manner due to the Sinhala and Tamil New Year season and it is a vacation period for school children as well as office workers.

4.3. WASTE BEHAVIOR IN THE ASPECT OF VOLUME

The degradable volume of waste generated in the Soysapura housing scheme is dynamic due to the waste content and the type of waste. But the non-degradable waste is not behaving in such a manner, instead, it is static and rigid. This rigidity results in generating free void spaces and negative volumes of waste.

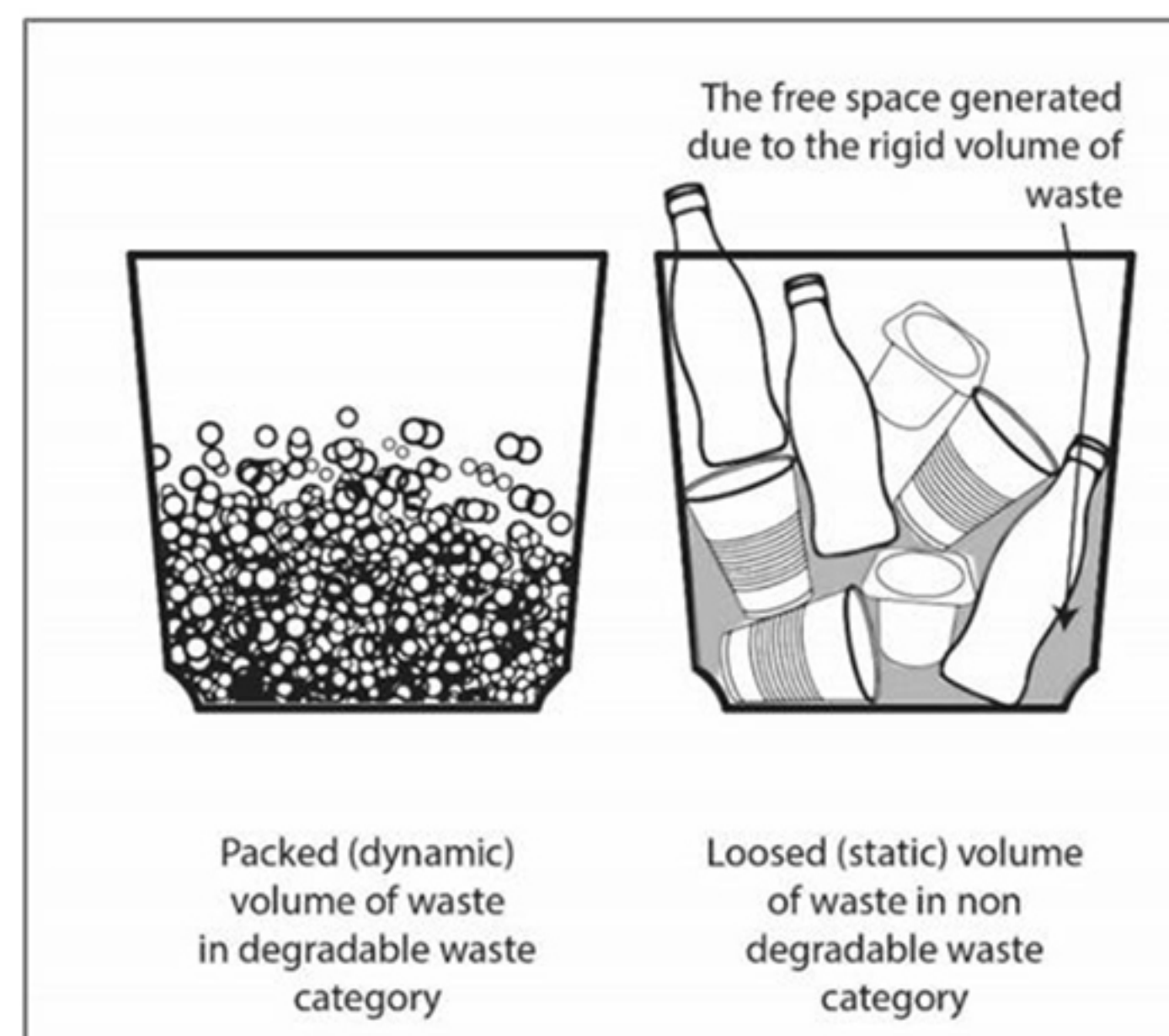


Figure 6, Waste volume comparison

Highlighting factor is that the non-degradable waste is making a huge sum of negative volumes. For example, the yoghurt cups and soft drink bottles can be considered. The material volume of a yoghurt cup is very much less than the overall volume it acquire in the space. Simply the negative volume is too much higher when compared with the positive volume.

Through the observations and studies it is clear that the negative volume of degradable waste is very less while non-degradable waste is very high in the studied context. This type of study is important in analysing the type of waste and the link between waste types and collecting methods. The analysis could pitch on four methods and the findings can be coordinated for a final conclusion over these four paths.

- Increase the volume of the collecting device

The size of the collecting device matters. As most of the house owners were restricted to a limited space and originally the houses were designed with chutes but not for other waste collection methods. And issues regarding handling will be aroused.

- Increase the number of collecting devices

It is not a proper solution for urban housing schemes like Soysapura. The space matters when the number of collecting devices is increased. And the house owners must find new areas of the house to place these devices. There is a

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trend of using this method by the ground floor house owners as they have a small land area but not for the upper floors.

- Manipulation of the space allocating for waste storing and collection

Using of Vertical and horizontal space is so much important fact in urban housing schemes. Especially the vertical space has more possibilities in collecting waste.

- Decrease the volume of waste generation

There are two aspects in reducing the volume of waste. They are pre generation of waste and post generation of waste. Most of the long-term and sustainable solutions seem to be with the aspect of pre generation. But the short term and most needed sudden solutions are in the aspect of post generation. Because many long chain processes must be studied and addressed in finding solutions in the aspect of pre generation. But the solutions can be easily and practically given in reducing waste after generation. And this type of waste management model will suit the present waste collection and storing issues in Sri Lankan context.

5. Conclusion

Through the above observations, studies and surveys, the combination of waste classification and waste volume reduction is the most suitable waste handling method for Soysapura housing scheme. Currently, the degradable waste volume of the Soysapura housing scheme is not making a huge impact on the waste collection method. The “green colour bucket” possess a volume of 18 litres. According to the survey, the approximate volume of degradable waste generated by a single family is 8.062 litres per day. It clearly suggests that the storing and collection of the degradable waste volume is not an issue when compared to the waste bin and the collection rate and process by the MC. But further studies must be carried in searching the ability to store degradable waste for several days. Current degradable waste volume convinces that the volume of the present device is very much high. In the other hand, new waste collecting devices can be designed to suit and handle the present volume of degradable waste. Even though the findings reveal that the impact of the volume of degradable waste is less on the present collecting device, the further studies must be carried to handle this volume of waste at the crucial levels of waste management in Sri Lanka such as landfilling and open dumping. Because the factors such as climatic conditions and chemical content can enhance the issue.

Even though the volume of non-degradable waste generated by a family per day is 5.828 litres it has impacted the Soysapura housing scheme in a severe manner. None of the present waste collection devices are suitable for handling the non-degradable waste volume. And inappropriate waste volume handling has directly caused the issues of waste such as open dumping, recycling and MC waste collection. The non-degradable volume of waste suggests that the contribution to these issues by the Soysapura housing scheme is countable and effective.

The present non-degradable volume can be linked with the theories and concepts such as zero waste and waste management hierarchy. For example, the zero waste theory can be modified and developed to suit present condition in Soysapura housing scheme in the aspect of waste volume. If the waste volume of non-degradable waste can be reduced to 1/4 of its actual volume there are huge possibilities in supplying sustainable solutions. Finally, the volume is a tool in achieving the targets related to Zero waste theory and waste management hierarchy. Rigidity and the static nature of non-degradable waste is high. The best solution will be reducing this rigidity and static nature of waste. Therefore the free voiding and negative volume of waste can be reduced to a great extent. This will directly responsible for developing waste collection methods while considering urban practices, a variation of the type of waste, the form of waste, the material of waste, space management and attitudes. Positive and negative volumes of waste must be considered. And a classification process must be developed while collaborating negative and positive volumes of wastes. The collecting devices and methods must be suitable for handling these positive and negative volume of waste.

Waste collection methods can be concentrated around the kitchen area and the collecting devices must suit the conditions and the layout of the kitchen. The relation of degradable waste and non-degradable waste is so much important in giving a unified solution for handling waste volumes.

The form of the waste matters when considering the volume, for example, the volume can be same for objects with two different forms but the impacts are different. Therefore the future studies must be carried on the forms of the products that later turns into waste. Especially in the aspects of the ability to stack, reducing volume, zero volume and reusable volumes.

If the volume of waste can be reduced, Moratuwa MC will be able to reduce the expenditure on the collection, fuel, transportation of waste and CO₂ emission. For example number of the vehicle turns and vehicles can be reduced and that monetary value can be invested in waste disposing and treatment.

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Following types of waste volumes and their relations must be considered when addressing urban domestic solid waste. Degradable and non-degradable volumes of wastes

- Positive and negative volume of waste
- Free void volume of waste
- Static and dynamic volumes of waste
- Low density waste volumes and high density waste volumes

The unit studies must be carried on other municipal councils and the waste generation places as the volume of waste is a prominent factor in explaining, studying and handling of waste. Finally, the collecting devices and methods can be considered as a crucial factor in handling domestic waste in Sri Lankan urban context.

6. References

- Bandara, N. J. & Hettiaratchi, J. P. A., 2010. Environmental impacts with waste disposal practices in a suburban municipality in Sri Lanka. *International Journal of Environment and Waste Management*, January, Volume 6, pp. 107-115.
- Hoornweg, D. & Bhada-Tata, P., 2015. *What a waste- A Global review of solid waste management*, s.l.: The World Bank.
- Ministry of Policy Planning and Economic Affairs Sri Lanka, 2015. *Census of Population and Housing 2012*, s.l.: Department of Census & Statistics Sri Lanka.
- S.Ilangovan, 2004. *Solid waste management in urban environment in Sri Lanka the case of Dehiwala-Moratuwa region*, Moratuwa: s.n.
- United Nations Environment Programme, 2005. *Solid waste management*. Nairobi: s.n.
- Vidanaarachchi, C., Yuen, S. & S.Pilapitiya, 2006. Municipal solid waste management in the Southern Province of Sri Lanka: Problems, issues and challenges. *Waste mangement*, pp. 920-930.
- Wijerathne, D. et al., 2012. *Solid waste generation, characteristics and management within the households in Sri Lankan urban areas*. s.l., s.n.
- Williams, P. T., 2005. *Waste Treatment and Disposal*. Second edition ed. West Sussex: John Wiley & Sons, Ltd.