

# Techniques for Better Management of Municipal Solid Waste Strategies: A Case Study of Moratuwa Municipality, Sri Lanka

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## Abstract

Effective implementation of Municipal Solid Waste Management (MSWM) strategies remains an issue in many developing countries. To analyse the effectiveness of the strategies, it is vital to understand the techniques employed to implement such strategies. Hence, this paper aims to analyse the techniques in implementing MSWM strategies in Sri Lanka. Single case study on Moratuwa municipality, which is considered as a critical case, was conducted. The study used a mixed approach; predominantly qualitative. Using purposive sampling method, semi-structured interviews were carried among 19 residents, one from each urban division of Moratuwa Municipal Council (MC), 03 MC officers, and 02 waste collectors. Additionally, 75 questionnaires were collected from residents. Code-based content analysis and quantitative statistical methods were used to analyse the interviews and questionnaires respectively. The community and MC have adopted various techniques in implementing MSWM strategies. Nevertheless, the community is not aware of some of the techniques enacted by MC. Strong communication between the MC officers and community, and between the different municipalities have been recommended for better management of MSW. The study has concluded by proposing some MSWM techniques that can be utilised by all municipalities in Sri Lanka as well as in other developing countries that face similar MSWM problems.

## Keywords

Case Study, Municipal Solid Waste (MSW), Municipal Solid Waste Management (MSWM), Strategies, Techniques

## 1. Introduction

In a world set out toward an urbanised future, the volume of Municipal Solid Waste (MSW), a huge result of the urban lifestyle, is expanding much more than the pace of urbanisation (Coban et al., 2018). The management of MSW has turned out to be an important matter for developing countries (Ihalagedara and Pinnawala, 2017). Municipal Solid Waste Management (MSWM) has been a crisis for a long time in Sri Lanka (Fernando, 2019). Appropriately managing the MSW is an unquestionable requirement to take out the hazard to human and environmental conditions. Besides, collecting and disposing of the waste is a basic issue in urban zones, particularly in Colombo and Kandy areas in Sri Lanka (Karunarathne, 2015). There are several strategies of MSWM all over the world such as Integrated Solid Waste Management (ISWM) (Environmental Protection Agency [EPA], 2016), solid waste management hierarchy (United Nations Environment Programme [UNEP], 2011), 3R (Abdel-Shafya and Mansour, 2018), 5R (Sha, 2017), etc.

The policies, strategies, and legal provisions provide the required basis for MSWM. A required legislative structure is provided for the environmental protection of the country by the 1980 National Environmental Act, subsequently amended in 1988 (Central Environment Authority [CEA], 2013). The National Strategy for Solid Waste Management initiated by the Forestry and Environment Ministry in 2002 to promote ISWM offers general guidelines for the management of MSW in the country. Though the requisite structure has been in place for a long time to establish an acceptable waste management system, MSWM is very chaotic in Sri Lanka, which is unfortunate (Bandara, 2011). Moreover, government agencies have sought over the last 20 years to define the country's best waste management plan. The CEA began in 2008 with the "Pilisaruru Program" a ten-year waste management system targeted at "Waste Free Sri Lanka by 2018" (Arachchige et al., 2019). Unfortunately, managing waste is still a significant challenge in Sri Lanka (Basnayake et al., 2019). Moreover, though there are studies undertaken to evaluate strategies adopted in

MSWM (Fernando, 2019; Ihalagedara and Pinnawala, 2017; Karunarathne, 2015; Samarasinha et al., 2014), there is a dearth of research specifically focusing on the techniques used to implement the strategies to manage MSW in Sri Lanka. There is no point of knowing the MSWM strategies, without knowing the proper implementation techniques of such strategies. Therefore, it is very significant to identify the techniques used to implement MSWM strategies in Sri Lanka as well as propose new techniques to enhance the current status of MSWM. Hence, this research aims to investigate the techniques for better management of the key strategies in MSWM in Sri Lanka.

## **2. Literature Review**

### **2.1 Significance of Municipal Solid Waste Management (MSWM)**

At the national level, waste such as food scraps, packing of products, furniture, newspapers, appliances, batteries, clothes, and grass clippings, which are generated in residences, schools, hospitals, and commercial sources can be defined as MSW (EPA, 2016). MSWM includes activities on arranging, engineering, organising, and managing the monetary and legitimate aspects involving the MSW process from generation, storage, collection, transportation, to treatment and disposal, by adopting an environmentally friendly approach that uses economic, aesthetic, energy and protection principles (Xiao et al., 2020). In Sri Lanka, residences, markets, and commercial institutions are the main sources of MSW while the hospitals and industries can be considered as secondary sources (Karunarathne, 2015). However, this study mainly focuses on MSW generated from the residential sector.

According to the CEA, Sri Lanka produces 7,000 Metric Ton (MT) of solid waste per day, and 60% of it represented by the Western province. However, only around 3,500 MT of waste is collected per day (United Nations Centre for Regional Development [UNCRD], 2019). Normally, each individual produces 0.4-1 kilograms of waste every day, even though only half of it is collected (Environmental Foundation (Guarantee) Limited, 2017). Therefore, there is a need for effectively managing MSW due to the limited capacity with waste collection compared to the increased waste generation. More than 90% of waste in low-income countries is mostly disposed in non-regulated dumps or publicly burned (World Bank Group, 2019). Such activities have significant effects on health, safety, and climate (Suleman, 2016). In Sri Lanka, MSW is gathered and dumped in dumpsites such as Karadiyana, Manampitiya, Bloemendhal, Gohagoda, etc. It can cause a variety of dangerous ecological effects such as groundwater contamination, air, and aesthetic pollution (Gunaruwan and Gunasekara, 2016). Nonetheless in Sri Lanka, as a developing country, there is a need to move towards a sustainable liveable city concept, where it includes long-term commitments to economic prosperity, human and environmental well-being (Bandara, 2011). Moreover, Sri Lanka has had enormous negative environmental consequences due to the lack of rigorous waste management national policies (Samarasinha et al., 2014). Although local authorities are implementing various programs on managing MSW, most of them have not yet succeeded (Fernando, 2019). Besides, the power currently authorised by the authorities is deficient to actualise an effective Municipal Solid Waste Management (MSWM) system in most developing countries (Zohoori and Ghani, 2017). Managing MSW is an important issue because it involves local municipal budget allocations, public acceptance, and adverse environmental impacts (Abdulredha et al., 2020). However, adopted strategies in MSWM in many developing countries are very confusing and require further analysis and strengthening (Eheliyagoda, 2016).

### **2.2 Municipal Solid Waste Management Strategies and its Implementation in Sri Lanka**

Obara and Ouko (2011) stated that properly implemented and operated MSWM strategies will finally lead to the proper management of MSW. There are a lot of MSWM strategies worldwide. The key strategies used in the context of residential MSWM in Sri Lanka are discussed below.

The EPA has developed a hierarchical structure for waste management to confirm that one single waste management strategy is not enough for managing the waste in all kinds of circumstances. Besides the hierarchy moves all waste management strategies from the most environmentally friendly to the least. The first step in the hierarchy which is source reduction and reuse refers to reducing waste at the source itself. It is the most environmentally friendly strategy from other strategies (EPA, 2017). Recycling is a set of exercises, including the gathering of utilised, reusable or unused products that would somehow or otherwise be viewed as waste; turning recyclable items into raw materials; and the recycling of reconstituted raw materials into new items (Ferrari et al., 2016). The converting of non-recyclable waste into usable energy sources such as gas, heat, electricity, and fuel using various procedures, including gasification, ignition, anaerobic absorption, and landfill gas recovery is meant by energy recovery which is the third

step in the hierarchy (UNEP, 2011). The final step is treatment and disposal, where before disposal, treatment can help to reduce the quantity and toxicity of waste. Landfills are the type of waste disposal, which is most generally accepted. Moreover, the lands can be utilised as recreational areas after the landfill is covered (Gertsakis and Lewis, 2003). Certain parts of this waste management hierarchy strategy are set up as customary practices built around waste prevention and recycling in a lot of developing countries (UNEP, 2011). In Sri Lanka, under National Policy on Solid Waste Management–2007, one of its key principles stressed that MSW should be managed adhering to the waste management hierarchy (CEA, 2014). Moreover, it was mentioned in the National Waste Management Policy that the waste should be managed according to the waste management hierarchy (Ministry of Mahaweli Development and Environment, 2018). However, the solid waste management policy has not been successful at its implementation stage due to some administrative problems such as insufficient land for final dumping, composting, and recycling (Liyanage et al., 2015); shortage of vehicles, other resources, necessary instruments, and modern technology (Samarasinha et al., 2014); lack of an integrated solid waste management programme (Bandara, 2011); poor regulatory framework; lower labour productivity and quantity (Fernando, 2019); lack of awareness of MSWM strategies among residents (Basnayake et al., 2019); and political interference in Sri Lanka (Environmental Foundation (Guarantee) Limited, 2017).

At the 3R Ministerial Conference held by the Government of Japan in April 2005, 3R Initiatives were formally implemented in Asian regions (Visvanathan et al., 2007). In Sri Lanka, there has already been the establishment of a 3-year implementation plan covered by the National Strategy for Solid Waste Management for 3R; Reduce, Reuse, and Recycle concept (Visvanathan & Norbu, 2006). The goal of 3R has become the only acceptable way to dispose of waste (Daniel, 2003). The concept suggests that the emphasis must be given respectively to reduce, reuse, and recycle against the usual practice of depending arbitrarily on the disposal of all solid waste in landfills (Diaz, 2012). This strategy can be facilitated by encouraging waste separation, which can be accomplished through financial motivations, legislative enactments, and environmental awareness programmes (Daniel, 2003). However, Fernando (2019) stressed that the 3R concept should be integrated into a national policy in Sri Lanka, which would allow the whole country to handle MSW on a sustainable basis. Besides, both national and local bodies who will cooperate with the policy simultaneously require a shared strategy. The Integrated Solid Waste Management (ISWM) strategy is aimed at developing institutional frameworks for effective waste management and sustainability (Tsai et al., 2020a). It is a comprehensive waste prevention, recycling, composting, and disposal programme (Fernando, 2019). The enhancement of ISWM involves concerted actions by the government, private sectors, residents, and other stakeholders from a system viewpoint (Hapilan et al., 2010). The implementation of the ISWM, which involved a mixture of many management possibilities and the use of state-of-the-art technologies, was demonstrated to be the best option for the existing solid waste problem (Wijetunga, 2012). The Ministry of Environment, CEA, and various government and non-government agencies in Sri Lanka have closely supported the ISWM (Fernando, 2019).

In Sri Lanka, several open waste dumping sites are currently in use all over the country (Maheshi et al., 2015). For the last 30 years, open waste dumping in Colombo Municipal area led to the escalating issue in an unsanitary eyesore in waste dump sites such as Kolonnawa, Bluemendhal, Meethotamulla and the diminishing of wetlands, coastlines, rivers, and other streams become open dumping spaces for plastic, polythene, and hazardous waste (Arachchige et al., 2019). However, with the collapse of the Meetotamulla dumping site, the waste management process is boosted to achieve targets with sanitary landfills such as Aruwakkalu and waste to energy projects (Environmental Foundation (Guarantee) Limited, 2017). Even though the waste management strategies have been included when developing waste management implementation plans (Visvanathan & Norbu, 2006) as well as national policies (Ministry of Mahaweli Development and Environment, 2018), the management of MSW is still an unsolved problem. Therefore an in-depth understanding of the techniques used to implement MSWM strategies as well as propose new techniques to enhance the current status of MSWM in Sri Lanka is vital.

### **3. Research Methodology**

Initially, a comprehensive literature synthesis was carried out to collect information on the concept of MSWM and the commonly used strategies in managing MSW in Sri Lanka. According to the Japan International Cooperation Agency (2016), the Moratuwa MC is the only local authority in Sri Lanka that introduced separate waste collection services in all its areas. As collection workers do not collect waste that was not discharged in the designated buckets, and the degree of residents' cooperation has been relatively high. Besides, the waste collection service is undertaken covering almost 100% of the geographical area of Moratuwa MC. Hence, Moratuwa MC was considered as a critical

case to conduct a single case study (Yin, 2018) to identify the good practices as well as the existing gaps associated with effective MSWM. A mixed research approach; predominantly qualitative, was adopted within the case study. Moratuwa MC consists of 19 urban divisions. A questionnaire survey was carried out covering 5 residents in 19 urban divisions of Moratuwa MC to identify the profile of waste generation and management. Out of 95 questionnaires distributed, 75 completed questionnaires were returned, making the response rate as 78.95%. The questionnaires distributed were translated into the local language to capture the information effectively. The questionnaires were analysed using descriptive statistical methods. Semi-structured interviews were then conducted with 19 residents (RH1-RH19) who represent each urban division in Moratuwa MC. Besides, interviews were also conducted with 05 MC representatives consisting of 03 MC officers (RR1-RR3) and 02 waste collectors (RC1 and RC2). Code-based content analysis was employed to analyse the semi-structured interviews. The purposive sampling method was chosen to select the respondents for both questionnaires and semi-structured interviews. The awareness and the current practice of strategies adopted in MSWM were analysed through the data gathered from the questionnaires while the techniques used to adopt the MSWM strategies were identified through interviews. The case study findings based on the questionnaires and interviews are presented in the following section.

#### 4. Findings and Discussion

This section presents the findings of the questionnaires on the awareness and the current practice of commonly used MSWM strategies in the context of Moratuwa MC. Also, it discusses the techniques used to implement the MSWM strategies which were derived from the qualitative interviews. Finally, the proposed techniques to improve MSWM are discussed followed by the conclusions and recommendations.

##### 4.1 Gap Analysis between Awareness and Practice of Different MSWM Strategies

In order to review waste management strategies adopted in MSWM, the awareness and the practice of commonly known waste management strategies were explored. The community awareness of different waste management strategies and to what extent such strategies are implemented in practice to manage the waste in their day-to-day life are presented in Figure 1.

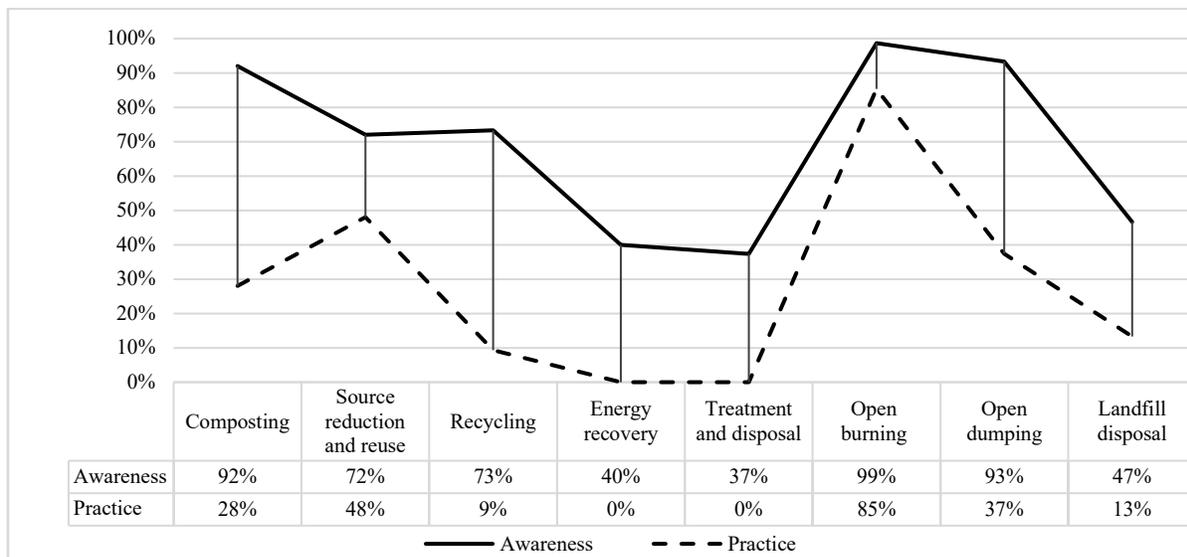


Figure 1. Awareness and practice in MSWM strategies

The awareness and practice of eight major MSW strategies were explored to identify community behaviour in managing MSW. According to the gathered data, open burning is the strategy that almost all the people are aware of. More than 50% of the respondents are aware of open dumping, composting, recycling, and waste reduction and reuse strategies. People are somewhat aware of landfill disposal and energy recovery strategies, while the least number of respondents are aware of the treatment and disposal strategy. When considering the practice of the strategies, Figure 1 clearly shows that even though people are aware of the waste management strategies, practicing those strategies in

managing waste is comparatively less. The open burning strategy has taken the highest position among all the strategies when considering its community practice as well as the awareness. Besides, it has the lowest deviation between the awareness and the practice, however, the open burning strategy is prohibited by the MC due to its adverse impact on the environment. All other strategies are adopted by less than 50% of the people, while none of the respondents is practising the energy recovery and treatment and disposal strategies that were the strategies that were least known by the residents. Gertsakis and Lewis (2003) stated that energy recovery, treatment and disposal strategies can be used to reduce the quantity and toxicity of waste. Therefore, more focus should be paid to those important strategies to increase the awareness as well as practice. Besides, the gap between awareness and actual practices of MSWM strategies are minimal with open burning followed by waste reduction and reuse. Other than those strategies, there is a big deviation among the practice compared to its awareness in all other strategies. The adopted techniques in implementing the MSWM strategies as well as the proposed strategies to improve the current status of managing MSW are discussed in the following sections.

## 4.2 Waste Management Techniques adopted in MSWM

The techniques adopted by the MC and the residents to implement the MSWM strategies were investigated through qualitative data analysis. The techniques identified under each strategy and commonly proposed techniques are summarised in Table 1. Direct quotations from the residents (RH), MC officers (RR), and waste collectors (RC) are also included in this section.

Table 1. Existing and proposed MSWM techniques

MSWM Strategies	Existing MSWM Techniques		Proposed MSWM Techniques
	Adopted by MC	Adopted by Residents	
Reduce Reuse Recycle	Waste collection procedure "Parisara pola" programme Recycling by waste collectors	Reducing the usage of polythene Reducing packaging Donating used items Income generation Reusing for different purposes	<ul style="list-style-type: none"> <li>• Enforcement of strict rules and regulations</li> <li>• Public awareness and education</li> <li>• Promote waste separating practice for the whole Sri Lanka</li> <li>• Government motivation on new products using MSW</li> <li>• Earn mutual trust between the community and MC</li> <li>• Promote new attractive concepts and technologies</li> <li>• Promote waste management pro-behaviours in social media</li> <li>• Private Public Partnership in MSWM</li> <li>• Formation of lane-wise committees</li> </ul>
Composting	Regulations enforcement Small scale composting	Domestic bin composting	
Energy Recovery	<i>No techniques are adopted</i>	<i>No techniques are adopted</i>	
Treatment and Disposal	<i>No techniques are adopted</i>	<i>No techniques are adopted</i>	
Open Burning* Open Dumping*	<i>No techniques are adopted</i> <i>No techniques are adopted</i>	Open burning Open dumping	
Landfill Disposal	Common dumpsite usage (Karadiyana)		
* Open burning and open dumping are prohibited by the MC			

The interviews revealed that there are no techniques used to implement energy recovery and treatment and disposal strategies in Moratuwa municipality, further confirming the lack of practice of those two strategies as presented in Figure 1. The MSWM techniques are further elaborated under the respective strategies below.

### 4.2.1. Reduce, Reuse, Recycling

**Waste collection procedure:** Waste collection is one of the most critical steps in managing MSW and local authorities are responsible for collecting waste on a regular basis (Eheliyagoda and Prematilake, 2016). Waste collection can be done either with or without separating the waste. All the respondents, who participated in the interviews stated that the common technique, which the council has adopted is waste separation. Waste separation has certainly played a crucial part in the MSWM (Pham Phu et al., 2018) and it is the primary activity to manage MSW (Fonseca, 2017). Besides, it not only greatly decreases the amount of waste produced at the source but also increases the waste characteristics that lead to the optimisation of waste management processes.

MC representatives stated that the waste collection procedure is happening regularly in the municipality, emphasising waste separation. The number of times the waste should be collected from a residence has been a key decision taken by the MC to avoid the discomforts due to waste accumulation at homes. Further, all residents are informed by the MC about the collection days and procedure. Hence, it has become a key technique in managing residential MSW. The degradable waste is collected by waste collectors during weekdays and twice a week from one residence, covering the whole municipality. The weekends are allocated to collect paper, polythene, PET bottles, rig foam, iron, glass, and tin wastes. All MC officers have given similar answers about the waste collection procedure emphasising *“we have provided a leaflet to all the residences in the area, informing about the waste collection procedure and we have distributed separate bins to every house as a motivation”*. Both the MC officers and waste collectors stated that the majority of the people are not supporting the waste collection procedure organised by the council. MC officers mentioned that the community thinks since they pay taxes, the MC has the responsibility to do the separation of waste by themselves. They further elaborated that, tax is collected not only for collecting wastes but also for other services such as electricity and water supply maintenance, repairing, constructing roads, etc. Their main claim was that the residents do not have a proper idea of social responsibility. In contradiction, the majority of the residents interviewed claimed that they are acting as instructed by MC. MC officers stated that to promote the collection of separated waste, a monetary incentive called *“Pohora Deemanawa”* is given to waste collectors if they bring only the separated waste from the residences. Further, the MC declared that there are loopholes in their waste collection procedure mainly in terms of lack of workers, equipment, and vehicles. For instance, due to lack of regular maintenance of vehicles, most of the existing garbage trucks are broken and this has created an adverse effect on the routine collection of waste. Besides, the malpractices of waste collectors are another issue caused to the irregular waste collection procedure. MC Officers elaborated that, *“we are receiving complaints from the community that collectors are favoured to the people, who give money to waste collectors”*. All the behavioural actions of the council, collectors, as well as residents, have collectively caused irregular waste collection procedures.

**“Parisara pola” programme:** Due to the increment of waste generation, there should be a proper way of managing waste, conducted by the MC (Abdel-Shafya & Mansour, 2018). The Moratuwa MC has taken several waste reduction strategies to manage MSW. For example, they conduct a programme called *“Parisara Pola”* where they collect unwanted things (waste) from the residents and put those for sale for those who need to use or recycle. This is to encourage the residents to dispose their waste in a proper manner. As an incentive, the residents who donate items to their fair will receive a Jack plant from the MC. It is a technique the council has implemented to promote reducing, reusing, and recycling habits in the community.

**Recycling by waste collectors:** The MC does not undertake any recycling activities. However, they promote this through waste collectors. Accordingly, polythene and paper wastes that are collected from residents, are sent for recycling directly by the waste collectors themselves without sending those to the MC. The waste collectors generate additional income through this activity. Considering this, the MC has allowed the waste collectors to send the recyclable items directly to the relevant parties, in order to successfully implement and to motivate the waste collectors with the recycling habits.

**Reducing the usage of polythene:** Polythene is a major kind of MSW and the amount of polythene production is a matter of great concern considering environmental safety (Grover et al., 2015). Hence reducing the usage of polythene is a significant technique. Interviewees have mentioned that using reusable bags instead of polythene bags as a technique to reduce and reuse. However, it was pointed out that even though the residents have bought reusable bags, they tend to forget to take those bags when going out for shopping next time. Another complaint was about the low durability of the reusable bags. It was brought up that the bag, which was used in earlier times, called *“Pan Malla”* (an environmental-friendly bag, which is made out of weed) is better than all the reusable bags today. However, the respondents declared that *“there is no trend of taking such bags for shopping nowadays”* (R3, R5, R11). The majority of the interviewees insisted that to reduce the wastage they reuse polythene bags, which come along with the product so that they can refuse additional polythene bags given by grocery shops. Some respondents mentioned that they give excessive clean polythene bags back to nearby shops for them reuse, rather than throwing. However, Joseph et al. (2016) stated that reusing polythene bags has been framed as unhygienic, even though this technique leads to less waste generation. A couple of respondents mentioned that as a practice they take a piece of paper to the supermarket and requesting to place the barcode for the vegetables and fruits on the paper itself rather than wrapping those using polythene covers. The respondents further stated that they got into that habit by watching another customer, who was doing that practice at the supermarket. Though they already knew the value of minimising the polythene usage, their behaviour and attitude were influenced by the behaviour of another person. The respondents believe that such

behavioural change is necessary if we want to realise the benefits of waste reduction. This implies that seeing someone's pro behaviour can influence in changing the attitude while creating a positive value to the environment. Like these customers, some sellers also following the good practice of not using polythene. For instance, those who sell pastry items using mobile food trucks ("*Choon Paan*") do not use polythene bags but paper to cover the food. As such, refrain from using polythene to wrap the food items when buying or selling has become a good practice to reduce the usage of polythene. However, this behavior is reflected only within a very few numbers of people interviewed.

**Reducing packaging:** Whenever an item is bought, waste is unavoidably generated due to its packaging (Hall, 2017), hence reducing packaging was identified as a major technique. Bulk purchasing (Beitzen-Heineke et al., 2017; Vallero, 2011) is another very good technique to reduce wastage, as buying repeatedly in smaller quantities of products will make the customers pay more as they also have to pay each time for all the packaging that is, however, sent to landfills at the end of the day. Besides, Chen (2019) had identified that food waste prevention is influenced by bulk buying. Few respondents emphasised that buying only what is necessary will help to reduce unnecessary waste that would otherwise be generated from the packaging.

**Donating used items:** It was insisted in the literature that the donation of items is also a technique that can be used to reduce wastage (Vallero, 2011). Supporting this view, it was emphasised during the primary data collection, donating clothes and other unwanted items provides the opportunity for someone to live on and at the same time to decrease trash in the home. It is reflected in the quote by RH1 as "*donating is better than throwing it out in the garbage, as it will end up in someone's closet, rather than in landfill*". Further, RH10 donate old books to the neighbours, who prepare paper bags for sale.

**Income generation:** Turning waste reduction into income generation is an incentive to encourage people to reduce, reuse, or recycle waste (Abdel-Shafya & Mansour, 2018). Some of the interviewees prepare paper bags in order to sell those to small scale shops. One respondent who is doing small scale sewing business uses the excessive paper wastage to cut blocks. Another respondent is making flower pots from paper waste. Further, there is a common practice of giving away the waste to those who collect glass items and papers from residences (famously known as "*bothal paththara*") in return for money. Besides, giving away the waste to a lorry for recycling purposes is another technique used by the respondents. Expounding the view it was stated by RH11 that "*though we can gain a very little amount of money by that, I think it is better than throwing away or burning*".

**Reusing for different purposes:** Reusing items for different purposes was identified as another technique followed by the residents. For example, growing plants in their garden by using coconut husks and tires and preparing table mats from paper pulps. Such practices are followed with the intention of reducing wastage at home. Besides, it was identified that most of the time, the residents do not throw food leftovers away, but give those to animals.

#### 4.2.2. Composting

**Enforcement of regulations:** MC has enacted a law for the residents, those who have more than 10 perch land area are not allowed to give their degradable waste to MC as they should prepare compost from that waste at home. However, RC1 mentioned that it is not always practicable to collect waste from only the houses, which have less than 10 perch area since there is no proper way of identifying the relevant houses. In agreement with that, RC2 stated that they gather any trash that people dump without checking whether or not they have more than 10 perch land area. Besides, though certain residents mentioned that they were doing composting, many of them are not aware of such regulation. This shows that though there is a law enforced by MC, there are gaps in the implementation and monitoring procedures. Therefore, a proper identification method, something like pasting a sticker on the front gates of the houses for the waste collectors to easily identify and refrain from collecting degradable waste from such houses, would be practical and beneficial to successfully implement the enforced regulation by the MC.

**Small scale composting:** Moreover, MC officers mentioned that compost is prepared by the MC but only on a limited scale especially from the waste generated from the daily fair located near the MC. This is because they do not have enough space to prepare compost from all the waste generated from the municipality. All the interviewees from MC officers and waste collectors mentioned that there is no large-scale composting yard owned by the MC to reduce waste generation. Therefore, the degradable waste is sent to Karadiyana Waste Management Centre governed by the Waste Management Authority. Further, it was mentioned that the capacity of the Karadiyana composting yard is also not enough as all the wastes from seven MCs are sent to this yard.

**Domestic bin composting:** Composting, which is a technique of recycling biodegradable waste (Fernando, 2019), is one of the major strategies that the community has adopted, despite an opposite idea has informed by the quantitative analysis. Waste generation can be minimised at home itself by composting. The respondents mentioned that they started preparing compost since there was no proper waste collection procedure earlier in the municipality. While the main reasons for composting are being improper collection procedure and having no time to dispose food waste, there are residents who wanted to compost for making organic fertilisers and they were influenced by the behaviour of others who had been composting. This implies that one's attitude has caused to create a pro-value in society. Nevertheless, there are a few residents who do not do composting. The most common reasons for not preparing compost are having no time and/ or no space. In addition to that, the geographical location has become a barrier to prepare compost for some residents. Emphasising the view, RH12 stated that, *"since I live near the riverbank, it is not possible to make compost in our soil"*.

#### 4.2.3. Landfill Disposal, Open Burning, Open Dumping

**Common dumpsite usage (Karadiyana):** The residual waste, which cannot be sold to another party, is sent to the Karadiyana waste dumpsite. However, as Karadiyana is a dumpsite under the waste management authority, it receives residual waste to dump, not only from Moratuwa MC but also from six other municipalities. RR1 stated that *"Moratuwa is the only municipality, maintains the separation procedure up to the standard level. When the other municipalities are not successfully separating, the final disposal is not a successful one"*. Moreover, the MC officers stated that Karadiyana is not a systematic disposal centre, as there is no sanitary landfill. RR2 further emphasised that *"in the near future, the mountain of waste in Karadiyana is likely to be a landslide"*. Therefore it can be considered as a critical issue if the waste disposal practices at Karadiyana dumpsites cannot be improved.

Apart from the waste disposal technique adopted by the MC, the residents have adopted burning and burying as the common strategies to dispose of their residential waste, even though those strategies are prohibited by the MC due to the adverse impact to the health as well as the environment (Ferronato and Torretta, 2019; Gutberlet and Baeder, 2008). Besides, some of the residents highlighted that they burn only tree leaves, and paper, but not polythene. One's perception of burning paper waste was preventing mosquito breeding. Moreover, it was mentioned by a respondent that usually all the waste in the home were either buried or burnt without separating the waste as they have enough space in the land. Further, some respondents stated that *"all the food residues are given to animals"*. Besides, some emphasised that all their kitchen scraps are directly put to the vegetable plants, grown in the garden, while another one buries the food scraps in their garden since MC collects degradable waste only once a week, which is contradicting with the MC representatives where they mentioned they collect degradable waste twice a week.

### 4.3 Proposed Techniques to manage MSW

Techniques proposed by the respondents for better management of MSW are listed in Table 1 and further described as follows.

**Enforcement of strict rules and regulations:** While open burning is prohibited by the MC, it is one of the strategies practiced by the majority of the people. This indicates that there are no strict regulations enforced by MC. According to RH1's idea, earlier, there had been no proper way for the MC to collect the waste in the area. The MC has collected the waste in a mixed manner. RH1 further mentioned that *"When they initially start the current collecting method; waste separation, it seemed like trouble to us and we did it only because municipality assigned us to do that. But now it is automatically happening"*. So, any kind of management improvement can be done through regular practice, and also through regulations. According to Tsai et al. (2020b), rules and regulations are crucial to the application of MSW, aimed at the regulatory execution of an effective MSWM strategy with a concise, clear outline, effective evaluation, and appropriate mechanisms. Further, RH6 stressed that *"the government should charge a fine from the people, who mismanage waste"*. According to RH7, *"fixing CCTV will be a good way to catch the people who throw garbage on the roadsides, and then people will not again do that due to shame"*.

**Public awareness and education:** The authorities have to organise awareness programmes on the adverse effect of mismanaging the waste, and also the benefits of managing MSW. Conducting awareness programmes on different waste management strategies and the benefits will be a great technique to change people's behaviours and attitudes. RR3 stated that *"the authority should educate the people at the regional level and the whole community has to engage"*

*with this process, otherwise, it will not be a success*". Moreover, waste management should be considered as a part of the school curriculum. When the children study the methods of managing waste and also the importance at a very young age, it will be instilled in their mind-set and when they grow up, it will be a norm and a part of their life.

**Promote waste separating practice for the whole Sri Lanka:** It was mentioned that only a few municipalities are in the practice of waste separation in Sri Lanka. Though the Moratuwa MC is properly undertaking waste separation before sending the residual waste to Karadiyana dumpsite, as the waste separation is not followed by other MCs when sending their wastes to Karadiyana, the final benefit cannot be realised. Hence the waste separation practice should promote the whole of Sri Lanka, not only for one or two municipalities.

**Government motivation on new products using MSW:** According to the residents, there is no support from the government to encourage them to promote their innovation. According to their point of view, half of the waste problem can be solved if the government motivates them and give financial incentives to the people, who make new products using waste. Moreover, the government has to find and promote economic benefits, which can gain from the MSW.

**Earn mutual trust between the community and the MC:** In order to manage MSW in a proper manner, support from both the community and the MC is vital. On one hand, the MC should earn the trust of the community by doing their job well so that the people will be motivated to support the council. On the other hand, the community should also show some interest and responsibility so that it will boost the waste management activities undertaken by MC. RH6 stated, *"regular waste collection should be done by the MC and waste collectors also should do their job properly when collecting the waste"*. Another suggestion, which came from the residents is to increase the number of the day of collecting food waste. RH16 elaborated on his issue that, *"since we live in flats, if the waste collectors do not come regularly we face a lot of trouble"*. Further, the waste collectors should always be inspected and supervised by the officers of the MC, who are accountable for managing the waste, to verify whether they are doing their work correctly. As such, when both community and MC earn mutual trust, the management of MSW will be effective.

**Promote new attractive concepts and technologies:** Residents stated that there is a fish-shaped structure, which is used to dump polythene, and plastic bottles in Panadura beach. People have to put those from the mouth of the fish. Because of that people indirectly get concerned about the lives of the sea creatures and also because of the new concept, people feel compelled to put polythene and plastic bottles into that. Those kinds of attractive concepts should be increasingly implemented in the future to improve waste management. Moreover, Small-scale compost machines and paper and plastic recycling machines should be installed in every division and the community should be motivated to practice waste composting and recycling habits. Moreover, a vehicle tracking system is a great way of identifying the location of the garbage tractor for both the officers and the residents, which can be implemented through a Mobile App. Besides, RR3 stated that *"from such technologies, we can catch the malpractices of the collectors"*. Currently, there are no treatment and disposal and energy recovery strategies undertaken by the Moratuwa municipality, hence the council officers suggested that techniques such as incineration and encapsulation should be implemented in order to treat the waste and recover the energy of it before the final disposal.

**Promote waste management pro-behaviours in social media:** It was revealed that people do not really get the value of managing waste. People only change their attitude by seeing the pro-behaviours of society. RH15 stated that as an example, *"earlier people, who went to see cricket matches did not clean the place before they leave. But some people started doing it. Then it was published on social media and the others also started doing that. Now, cleaning the premises before leaving has become a trend"*. Therefore, to improve waste management, an attitudinal change is required. According to RH15, the attitudinal change can be achieved by seeing others' pro-behaviours.

**Private Public Partnership in MSWM:** RR3 mentioned that *"if outside private companies engage in managing solid waste, the waste problem can be easily solved"*. If there is an investor, who likes to invest in the generated waste, it will be a huge solution to manage MSW in the Moratuwa municipality.

**Formation of lane-wise committees:** Forming lane wise committees is also would be a great technique to manage MSW in the municipality to ensure public participation in waste separation and deposition of domestic waste in their own bins at a fixed time without any interruptions to waste collectors during primary collection. When there is a representative from a lane, that person is responsible only for managing the MSW of their lane. Besides, when an authorised power is vested on the committee, they can maintain waste management practices continuously.

## 5. Conclusions and Recommendations

The community in Moratuwa municipality as well as the MC have adopted various techniques in implementing the MSWM strategies, which can be introduced to the whole Sri Lanka. However, the community is not aware of some of the techniques enacted by MC. Therefore, if a proper channel of communication is in place to enable the communication between the MC officers and the community, the implementation of the techniques will become more effective. Also, as highlighted in the discussion above, when only one MC follows the proper waste separation and management techniques it might not be good enough to achieve the waste reduction, while the other MCs do not use such techniques. Hence, the good practices followed at Moratuwa MC should be transferred to other MCs in Sri Lanka. To facilitate this, stronger collaboration and communication between the municipalities are essential for better management of MSW in Sri Lanka. It was further revealed that the community has adopted some MSWM techniques by seeing others' behaviours and through social media. Therefore, the researchers suggest using social media as a channel to acclimate society into good waste management practices. Further, based on this case study, it was revealed that none of the community and the MC has adopted any of the techniques in order to implement energy recovery and treatment and disposal strategies, even though such strategies are very significant in MSWM. Therefore, the awareness, as well as the practice of these strategies, should be improved in achieving the proper MSWM process. Moreover, some techniques were proposed by the respondents, which can be used to solve the national problem in MSWM. If all these suggestions are adhered, then the real benefits of effective implementation of MSWM can be realised. Though the study is focused only on Moratuwa Municipality, the existing, as well as the proposed techniques to manage MSW, can be utilised in other municipalities in Sri Lanka to solve the national level problem in waste management. The management of MSW has turned out to be an important matter for most of the developing countries. Thus, as an initial output, this study can be benchmarked to other developing countries, which have similar waste management problems for the effective management of MSW by applying the existing and proposed techniques to manage MSW.

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