**SAMODHANA JOURNAL**
Faculty of Social Sciences and Humanities,
Rajarata University of Sri Lanka,
Mihintale

**2021** **Volume 10** **Issue I**

# Sri Lanka Can Prosper by Converting Waste to Energy: with Special Reference to Colombo Municipality

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Received Date: 05th July 2022
Accepted Date: 10th March 2023
Published Date: 06th June 2023

## Abstract

Waste-to-Energy is one of the most popular approaches to reducing municipal solid waste in developed and developing countries today. The Waste-to-Energy concept is the latest one that Sri Lanka currently focuses on. Colombo Municipal Council (CMC) views the concept of Waste-to-Energy through which Sri Lanka can prosper by generating energy sustainably from its waste while managing it in an environmentally friendly manner. The general objective is to investigate how Sri Lanka can prosper by converting Waste-to-Energy based on the solid waste in the Colombo Municipal Council. Mixed methodology method was adopted and both qualitative and quantitative data collection methods were used. Thematic analysis was used for the analysis of qualitative data. The current solid waste management system of the Colombo Municipal Council is not fully systematic and still problematic. However, the waste-to-energy power plant, which was created as a first step based on the CMC, could be identified as an existing successful project. In view of the above, it can be concluded from the special mention made in connection with

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CMC that Sri Lanka can mainly prosper by converting the waste generated into Waste-to-Energy.

**Keywords:** Waste-to-energy, CMC, Renewable Energy, Solid Waste, Energy Demand

## Introduction

Today, the main concern is focusing on alternative energy strategies for the stability of the future world. Most importantly, these non-conventional renewable energies are generated according to environmental consistency and in an eco-friendly and eco-related way. Thus, this alternative energy or non-conventional renewable energy has already become one of the most attractive energy substitutes in the world. This is basically due to global warming effects and the rapid depletion of natural resources in conventionally generating energy. With non-conventional renewable energy, we do not have to deplete or destroy natural resources. Hence, these non-conventional renewable energy sources are gaining more and more attention.

The Sustainable Development Goals (SDGs) have been introduced to achieve the 17 goals. There is a strong link between solid waste management and the Sustainable Development Goals, which has great significance. Sustainable development goals cannot be achieved if waste management is not a priority. That is specially done through the concept of Waste-to-Energy, which can simultaneously provide solid waste management and sustainable solutions to the energy crisis. Recent research identified urban solid waste as an excellent non-conventional renewable energy source due to its various compositions. The world currently generates 2.01 billion tons of urban waste, which is expected to grow further by 2050 (Kaza, et al., 2018). This increase in global solid waste is due to consistent economic development, population growth and urbanization of the world. Sri Lanka is a developing country. Developing countries like ours are facing rapid urbanization worsening the solid waste management issue.

Moreover, simultaneously, the said circumstances of rapid urbanization in developing states create energy crises and various socioeconomic and environmental issues. Sri Lanka emits more than 9000 MT of solid waste daily, of which 60% are decomposed materials, and the rest is non-decomposed. About 400 MT of 40% of non-decompose materials are

discharged into the environment as plastics and polythene. Other substances include environmentally harmful batteries, electronic wastes, and clinical and chemical wastes (Ministry of Health, 2020).

CMC is the largest and most developed local government body in Sri Lanka. Moreover, it is the city which is most rapidly urbanizing. Accordingly, the amount of waste generated daily is approximately 900MT (Nuzrath, 2017). Of this, 500MT is the daily solid waste generated by the people living in the CMC (Colombo Municipal Council, 2015). Thus, the Colombo District alone generates about 70% of the island's solid waste (Nuzrath, 2017). Mainly, urbanization contributes to the disposal of solid waste management. As mentioned above, not only the waste problem is the energy crisis, another complex issue Sri Lanka faces. The growing energy crisis and the waste problem are significant obstacles to the sustainable development of Sri Lanka. According to the 2019 Annual Report of the Ministry of Power and Energy, the total annual electricity generation of 2018 in Sri Lanka was 15,925 GWh. The daily average electricity demand of Sri Lanka was 42.66 GWh, and the maximum daily power consumption was 45.86 GWh. The total annual electricity demand in 2019 was 17,285 GWh (Karunanayake, 2019).

The Government of Sri Lanka has undertaken several solid waste management initiatives, and the Waste-to-Energy concept is the latest one that Sri Lanka is currently focusing on. CMC reviews the concept of Waste-to-Energy through which Sri Lanka can prosper by generating energy sustainably from its waste while managing it in an environmentally friendly manner. Waste-to-Energy is one of the most popular approaches today to reduce this urban solid waste. Countries worldwide are increasingly embracing this concept, making it a more popular approach to environmentally Friendly Waste Management and Non-conventional Renewable Energy production as the most effective alternative to economically, environmentally and socially prospering (Ministry of Health, 2020). The first Waste-to-Energy Power Plant was established in Kerawalarapitiya as the initial step in Sri Lanka to use knowledge, technology and proper control methods to manage waste by producing energy.

The research question in this study is how Sri Lanka can prosper through the Waste-to-Energy concept. This new technology manages the existing solid

waste in the Colombo Municipal Council and other cities in an environmentally friendly manner and converts it into energy.

This general objective is to investigate how Sri Lanka can prosper by converting Waste-to-Energy based on the solid waste in the Colombo Municipal Council. Specific objectives of this study; include gaining a comprehensive understanding of the existing solid waste management and energy generation in Sri Lanka, a study on current solid waste and energy levels in Sri Lanka and its environmental, social and economic impacts, the study of the cost-effectiveness of Waste-to-Energy, identify the composition of Colombo municipality solid waste and Sri Lankan solid waste and its total volume through Primary and secondary sources.

Accordingly, this study focuses on the CMC and reviews the concept of Waste-to-Energy through which Sri Lanka can prosper by generating energy sustainably from its waste while managing it in an environmentally friendly manner.

## Literature review

Today, the concept of waste is an extensive perception. It can be defined in many ways when it comes to defining waste. Waste is generally defined as a substance or object that the person who created it wants to dispose of. The United Nations Statistics Division (UNSD) on Environmental Statistics defines "Wastes are materials that are not prime products for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded." (Wikipedia, 2022). Presently world creates massive quantities of waste, which causes many environmental, social and economic problems. As a peasant, it is quite the opposite that the society, due to overconsumption of resources, generates a huge amount of waste. Waste depends on urbanization, population growth, technology, inhabitants' culture and traditions, consumer or community lifestyle, food habits, climate and economic conditions.

The waste material that human society throws away on their daily consumption can be called solid waste. Solid waste includes municipal, industrial, agricultural, biodegradable, and radioactive waste. According to the United States Environmental Protection Agency, Solid Waste is any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material resulting from industrial, commercial, mining, and agricultural operations, and from community activities (United State Environmental Protection Agency, 2021).

Among the waste problem, urban waste can be found in all countries. Accordingly, With the increase in population density in urban areas, it is observed that urban solid waste or municipal solid waste is increasing exponentially day by day. As a clear definition of municipal solid waste, we can define municipal solid waste can also be described as a by-product of the consumer-oriented lifestyle that drives most of the world's economies. As living standards and disposable incomes increase, so does the consumption of goods and services, resulting in a corresponding increase in waste generated (Hoornweg & Bhada-Tata, 2012).

When considering urban solid waste, MSW can be divided into two parts, developed and developing countries. Focusing on the generation of MSW in the world, the amount of waste generated in developing countries is relatively higher than in developed countries. Based on the United Nations Population Sector estimates and the World Bank's GDP, the total MSW will increase from 13 billion to 27 billion tons by 2050 ( Karak, Bhagat, & Bhattacharyya, 2012). At present, more than 17 million tons of MSW are generated annually. People generate at least 1.2kg of waste daily (Hoornweg & Bhada-Tata, 2012). All of these MSWs are manufactured in developed and developing economies. Waste generation is high in developed countries such as Europe, America, Asia and Australia. MSW generation and the amount of waste one person produces yearly are large. Most Asian and African countries fall into the category of developing countries. These countries generate the largest amount of waste in the world. According to Tanmoy Karak's research, by 2025, waste in developing Asian countries will increase by 1.8 billion tons. Furthermore, India will increase by 16.6 million tones MSW by 2026. It is said that 14.5 million tons of MSW are generated now in African countries ( Karak, Bhagat, & Bhattacharyya, 2012).

Researchers said, With the rapid growth of Asian countries, this problem is exacerbated as people in those regions seek to improve their living conditions and change their consumption patterns. Hwa stated in 2007 said that the low levels of awareness, lack of technical knowledge, strong policies & legislations, and proper plans & strategies for MSW are the major challenges in low-income countries in Asia (Silwal, 2019). Third-world countries, in particular, are taking a leading role in this. All countries worldwide need to look at this environmental issue critically to achieve its critical role in protecting the environment and improving productivity and effective urban solid waste management.

Sri Lanka, being a developing country, suffers greatly from these challenges. Urban waste accumulates in large in many urban areas in Sri Lanka & its collection and disposal is a serious problem. According to the study by Nilanthi J.G.J. Bandara in 2004, per capita waste generation in Sri Lanka is 0.85kg per day in the Colombo municipal council (CMC), 0.75kg in the other Municipal Councils, 0.60kg in the Urban Councils and 0.4kg in the Pradeshiya Sabha. She says that by 2025, the MSW generation rate will increase to 1 kg per person (Bandara , n.d). Accordingly, the total waste generation in Sri Lanka is 8000-15000 MT daily. That is 4.5 million MT per year. According to the JICA National Solid Waste Management Report, the amount of waste collected daily by 311 local authorities is 2838 MT. That is annually 1.04 million MT (Gunaruwan & Gunasekara, 2016). The biggest challenge is how the waste generated due to these reasons is collected and disposed of by the local authorities. The most common disposal method in Sri Lanka is open-dumping, open-burning, and landfilling. MSW are unwanted disposals in Sri Lanka, resulting in loss of wetland habitat, destruction of flora and fauna, pollution, health problems, etc. In particular, greenhouse gases such as carbon dioxide and methane are released into the atmosphere, causing changes in the climate.

Although a good MSW management system has been introduced in Sri Lanka, local authorities do not properly implement, maintain, monitor and evaluate it. Therefore, this has become a national issue. Several laws and regulations have been enacted regarding waste in Sri Lanka. Among them are the National Environmental Act No. 47 of 1980, the Pradeshiya Sabha Act No. 15 of 1987, the Municipal Council Act No. 31 of 1939 and the Municipal Council

Ordinance No. 16 of 1947. Accordingly, it is unfortunate that waste management is still slow, despite many favourable laws. Sri Lanka has a good policy framework; neither the public nor the officials know to understand it. In addition, the relevant officials do not have adequate training and knowledge about the management of MSW. They do not engage in social partnerships and do not encourage their residents. Therefore, the concept of 'we dump - they collect' has been formed in society (Karunarathne, 2015).

Accordingly, although several projects are in operation in Sri Lanka, considering the Colombo Municipal Council of Sri Lanka, these problems are more prevalent than in other urban areas. The Solid Waste Management Division of the CMC Department of Urban Engineering oversees MSW Management. Under the supervision of that management, MSW is divided into three, i.e., biodegradable, recyclable and non-recyclable. According to a study by A.N.N Nuzrath and Dr Fareena Ruzaik relevant to the CMC area, residents dump waste into open spaces, water sources and drains when there is no infrastructure to collect waste. Although many residents are concerned about the environment, there is a lack of involvement in domestic solid waste management processes and all stakeholders (Nuzrath & Ruzaik, 2017). The management is not sustainable due to a lack of awareness, support from the authorities and a lack of landfill to dispose of the waste.

Various worldwide waste management programs are already underway. Sustainably reduce the wastes generated while minimizing the increasing consumption of human beings. Changing the attitude of the public towards consumption is a key factor. There is a significant point to be made before managing MSW. According to Sristi Silwal's research, many European countries use Integrated Solid Waste Management (ISWM) for waste management. The special reason for this is that the above characteristics of the generated waste are intertwined. Then the amount of waste they take to the landfill or disposal area is very small (Silwal, 2019). Many industrialized nations follow the "Waste Management Hierarchy" philosophy in developing MSW management strategies. It is currently being used not only in industrialized countries but also in developing countries. Accordingly, this could be referred to as a menu for developing integrated strategies for MSW management. It consists of 5 different components. There is prevention, reuse, recycling, recovery and disposal. In addition, the world uses many new

technologies. There are; Open dumping, Landfilling, Open Burning, Composting, etc. These technologies always apply in Sri Lanka. The technology of Waste-to-Energy is a new one that applies in Sri Lanka.

In 1903, Waste-to-Energy (WtE) technology was introduced in the history of the world in Denmark as a combustion technology (Silwal, 2019). Waste-to-energy, which generates energy from solid waste converted into electricity, heat or fuel, is a rapidly growing system worldwide. Generating energy using machines through this method can be considered a commercial business opportunity. With the ability to convert Waste-to-Energy, waste can be transformed into an economically valuable resource, providing sustainable solutions to the energy crisis and reducing environmental pollution. The remaining resources at the end of the process can also be used as resources.

MSW can be converted to power according to various WtE conversion processes, such as thermal treatment technology and biological treatment technology. Thermochemical conversion is used for low-moisture waste, and biochemical conversion for high-moisture waste, such as organic waste. It is common for many low-income countries to deal with large-scale environmental problems and energy crises. Accordingly, using WtE technology in MSW can be defined as a technology that contributes to energy recovery by converting it into other alternative fuels such as heat, electricity or biogas. WtE technology is a new solution to the uneven distribution of energy. It will also help alleviate the long-running energy crisis in developing countries. According to Richa Kothari and others, WtE technology has made it possible for developing countries to access sustainable renewable resources through alternatives such as biogas technology and hydrogen energy from solid waste generated from various activities to reduce the unequal energy distribution and energy crisis in the world (Kothari, Tyagi, & Pathak, 2010). The initial costs and infrastructure involved in implementing this technology are expensive. However, there is potential for capital development through WtE technology. Even if the start-up costs are high, the benefits can be reaped later. Research on this technology must be compiled and documented. Because it helps future generations with a great deal of information about its progress, researchers' attention, and new technology.

## Materials and Methodology

### Study Area

Colombo, the main commercial capital of Sri Lanka, is located south of the Kelani River on the island's southwest coast. This Colombo area is bounded on the north by the Kelani River, on the south by the Dehiwala Canal, on the east by the Kelaniya, Kolonnawa and Sri Jayawardenapura Kotte Pradeshiya Sabha areas and on the west by the Indian Ocean. This Colombo District is made up of three main Municipal Councils. Namely, Colombo, Dehiwala-Mount Lavinia and Kotte. Accordingly, this study has been conducted based on the Colombo Municipal Council area consisting of 47 urban wards. This study area (CMC) is located between east longitude $99^{0}50'$ - $79^{0}59'$ and northern latitude $6^{0}50'$ - $6^{0}60'$ (Matharaarachchi, Manawadu, & Gunatilake, 2016). The Colombo Municipal Council covers an area of 4361.6 hectares and falls under the administrative boundaries of the Colombo and Thimbirigasyaya District Secretariats. That is, the city covers an area of 37 square kilometers. The lowest administrative unit, 55 Grama Niladhari Divisions, is also included in this limit. Its administration is divided into six districts.

The residential population of the Colombo Municipal Council is between 555,031 - 561,314. More than 600,000 people from different parts of the country migrate daily to the Colombo Municipal Council area for various purposes (Colombo Municipal Council, 2015). The population density of this area is 115 persons/ha, according to 2017 records. According to 2012 reports, CMC has a Total number of households of 122,421 and a total number of housing units 118,594. From it, there are 110,467 permanent houses, 7915 semi-permanent houses, 171 improvised houses and 41 not-classified houses. According to this study area, the number of houses covered by garbage collection is 120,313, and the number of houses not covered by garbage collection is 2108 (State of Sri Lankan Cities, 2019). Thus, population growth, migration and land use and Spatial patterns in the Colombo Municipal Council, the commercial capital of Sri Lanka with a democratic society, can be understood from these data.

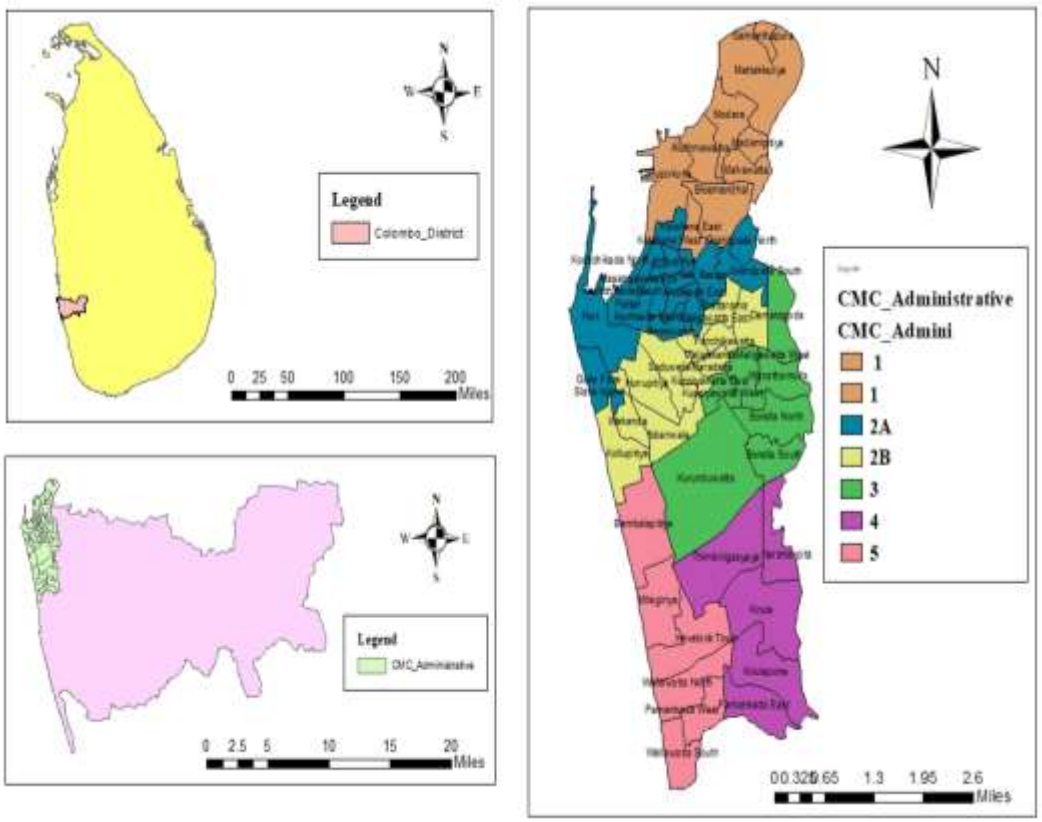


Figure 1: Administrative Districts of the Colombo Municipal Council, 2022

## Data Collection

Data is the most important section to conduct research and make it successful. Qualitative data is generally in words, and quantitative data is in numerical form. Due to the use of both quantitative and qualitative data types for this research, the study was conducted under a mixed-method strategy. Mainly, focused Qualitative method. Quantitative and Qualitative data were obtained under two categories, such as primary and secondary data. Therefore, as primary data, qualitative data were collected through field observation and semi-structured interviews and qualitative and quantitative data were collected through a questionnaire. As secondary data, research articles & journals, public books & textbooks, government annual reports & document and website articles & etc., were used for research.

For this research, data were found using semi-structured interviews. Accordingly, data was collected through semi-structured interviews with senior officials and employees of the Waste Management Authority, the Colombo Municipal Council, and Sri Lanka's first Waste-to-Energy power plants. The answers and special facts collected from these interviews were noted, and it also used an audio recorder with the permission of those agencies to verify its accuracy. Both types of qualitative data and quantitative data were collected through a questionnaire for research. In this study, questionnaires are divided into three categories. That includes general information, solid waste generation by residents and solid waste collection in CMC, solid waste-related issues, and management. It was possible to inquire about the public's awareness, attitudes, needs and interests regarding waste management. As the CMC is spread over a wide area, a sample was required to provide the questionnaire. Accordingly, a simple random sampling method was used as a sampling method for presenting this questionnaire. The 100 residents who came to the CMC office were randomly selected and presented with a questionnaire. Field observation methodology was used to collect primary data for this research. The non-participating observational method was used for this research. The field of study was monitored as it was necessary to understand and gain adequate knowledge about the waste of the area and the impact of pollution on good environmental development. Non-participatory observations could verify the information gathered from the questionnaire and semi-structured interviews. Secondary data can be used for this study. Secondary data was used to review the study literature, identify the study area, understand the research subject, formulate research questions, and much more.

**Data Analysis**

After obtaining data for research, the next important stage in the research process is data analysis. The whole study depends on this analysis. This is a completely mechanical procedure. Questionnaires, semi-structured interviews and field observations are integrated through the data analysis. Before beginning the study analysis, all the collected data were properly recorded. The data was then encoded for classification and analysis according to its content. However, since qualitative and quantitative data are used for this research, different methods were used to analyze them.

Thematic analysis, one of the most common qualitative data analysis methods, was used for this research. Accordingly, the qualitative data thus collected was subjected to a thematic analysis under four steps. First, this raw data was cleaned up to start. There took out the first found data and arranged them in order. Facts irrelevant to the research were removed, and Necessary facts were carefully or well-prepared. Thus, the selected data were subdivided into subcategories. The same subcategories were then clustered or chunked. It is then coded. Finally, according to how the data is represented, it is observed, and the conclusion is drawn. Microsoft Excel 2016 was used to analyze the quantitative data collected. This software analyzed the data, and the relevant results were obtained. Graphs, flow charts and tables were used to represent the result obtained through this software. It can manage large amounts of data.

**Methodology Framework**

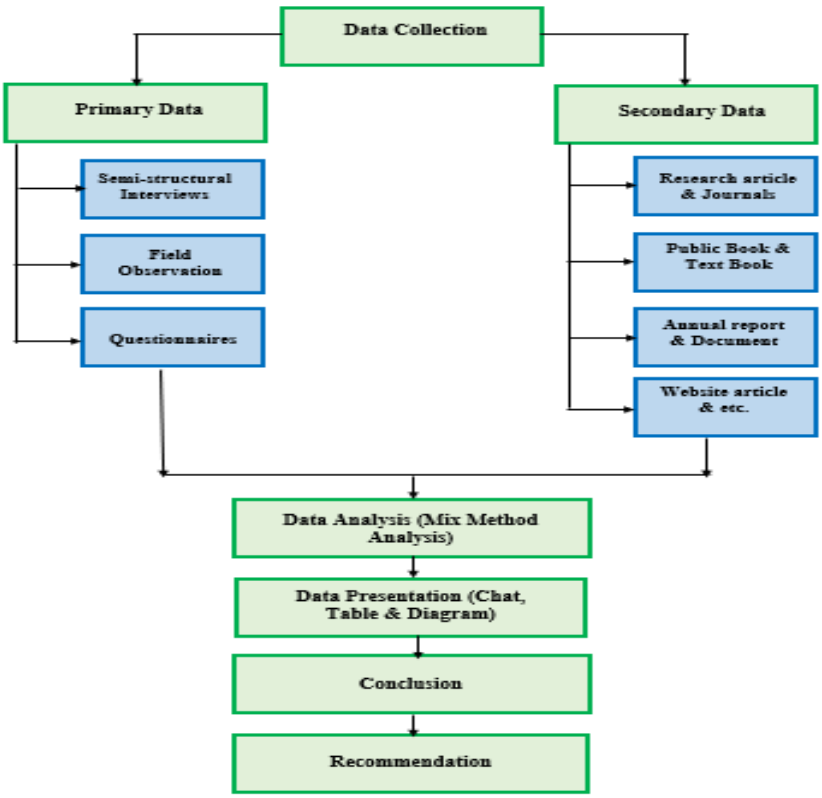


Figure 2: Methodology Framework

## Result and Discussion

As mentioned above, CMC has made efforts to manage solid waste and related issues in its territory. However, there are some weaknesses due to its institutional contradictions. The municipal authorities found a gap that needed to be effectively addressed. There is a crisis here because the public, private sector and public opinion do not match. This study examines CMC's waste management, public perceptions, and Waste-to-Energy power plant progress.

Today, the area collects between 450MT and 500MT of waste per day. Last year approximately 900MT of waste was collected per day, and after 2021 that volume will be around 450MT (Ministry of Health, 2020). The main reason for this waste reduction is the construction of the Waste to Energy power plant. There are no reports of waste being classified. Previously, domestic, corporate and commercial waste collection was done. However, due to the supply of waste to energy power plants, there will be no segregation as before.

Furthermore, there are no separate reports on the composition of the waste. This is because the plant carries non-perishable waste such as glass, iron, black stone, pottery, porcelain and all other waste except hospital and electrical waste. According to the data collected through the questionnaire, CMC waste is currently segregated under three methods—organic, non-recyclable, and recyclable. Most of the organic waste, in addition to polythene, plastic and paper, is collected here. The graph shows 60% organic waste and 35% non-recyclable waste. The remaining 5% is a recyclable material. Since plastics, polythene, and plates can earn extra income, the employees working in CMC give the waste to those places and earn income.

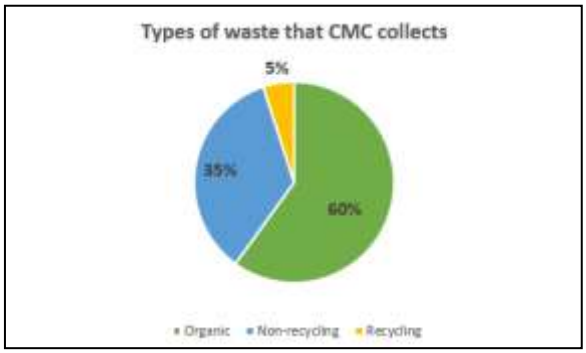


Figure 3: Type of Waste that CMC collects
Source: Field Survey, May 2022

In a survey of generated household waste, Data from humans also indicate that organic waste is being generated in large quantities. As this represents, most household waste is organic waste. The second is generated by polythene, and the third is paper. Finally, there are glass and other waste. Thus, it seems that organic waste is the type of waste that has become a significant problem in this area.

Table 1: Composition of waste in CMC

| Waste type | Highest | Second | Third | Fourth | Lowest |
|---|---|---|---|---|---|
| Organic | 83 | 8 | 2 | 2 | 5 |
| Polythene | 11 | 47 | 34 | 6 | 2 |
| Paper | 0 | 41 | 57 | 1 | 1 |
| Glass | 1 | 4 | 4 | 64 | 27 |
| Other | 5 | 0 | 3 | 27 | 65 |

Source: Field Survey, May, 2022

As this represents, most household waste is organic waste. The second is generated by polythene, and the third is paper. Finally, there are glass and other waste. Thus, it seems that organic waste is the type of waste that has become a major problem in this area.

Here, the waste collection takes place effectively in this region. It was much clearer in the survey that was done. Here, the result is that 93% of the waste is collected through CMC, and only about 7% of the waste is not collected. Thus, waste collection is done on different days through the Colombo Municipal Council. There, waste is often collected through the CMC every three days. About 40% of respondents said the CMC visits every three days to collect their waste. Mahawatta, Modara and Mattakkuliya are good examples. CMC comes in for only 32% of the daily waste collection. The survey confirmed that waste is collected daily in the main cities of the Colombo Municipal Council.

The average household generates 5 - 10kg of waste daily or weekly. 34% of respondents generate 5kg of waste. 33% of 10kg of waste generates an amount of waste. Accordingly, most people living in the CMC area generate between 5kg-10kg of waste per day or week. In addition, 32% of households generate 15kg of waste. Most people in CMC dispose of waste through 62% polythene bags. In addition, large quantities of waste are disposed of through the Basket

/ Bucket. This increases the amount of waste and polythene that accumulates. Several factors cause the disposal of it in polythene bags. That is because it is a substance that should be discarded after use. After all, it is easy to store because it is easy to dispose of, etc., do the respondents raise the main ideas.

This separation is done into organic waste, non-recyclable waste and recyclable waste. Here organic and non-recyclable waste is added together. This is because all that waste goes to the Waste to Energy plant. CMC is collected waste use of Compact trucks and tippers, giving to door-to-door visitors, handcarts, dumping in bins set up in the city, delivery to secondary collection points, and more. Most of the waste collection in CMC is done by compact trucks and dump trucks. According to data from respondents, it carries 52% of its waste through this method. In addition, handover is done to those who come from house to house. It is 27%. CMC does Slight waste removal through other methods.

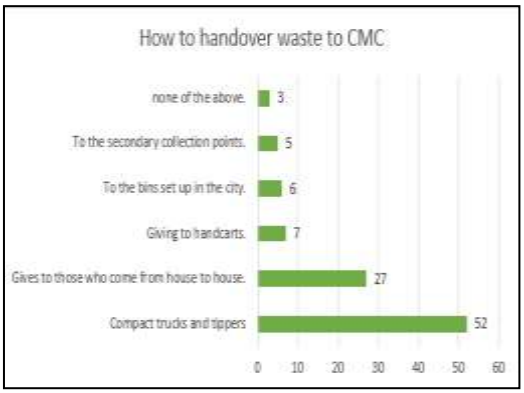


Figure 4: How to Handover waste to CMC
Source: Field Survey, May 2022

Table 2: How to Handover Waste in CMC,

| How to collect waste | Frequency | Precentage |
|---|---|---|
| Compact trucks and tippers | 52 | 52% |
| Gives to those who come from house to house. | 27 | 27% |
| Giving to handcarts. | 7 | 7% |
| To the bins set up in the city. | 6 | 6% |
| To the secondary collection points. | 5 | 5% |
| none of the above. | 3 | 3% |
| **Total** | **100** | **100%** |

Over the last few years, waste has been disposed of at Blumenthal, Muthurajawela, Madampitiya and Aruwakkalu landfills. The damage caused by there is huge. The main reason for the large accumulation of waste in the Colombo Municipal Council, legal protests and public protests against it, the dumping of waste was stopped in these lands. Madampitiya waste dump is the only landfill currently in operation. The landfill is located in the middle of 5,000 family units. Not only in the waste dump but also on both sides of the roads where the waste dump is located, there is a great threat of waste disposal by outsiders (Colombo Municipal Council, 2015).

Figure 5: Madampitiya Dumping Site, Source: Field observation, May 2022

Here, the price of a ton of mixed waste is Rs. 2500; for non-mixed waste, Rs. 3500 is required by CMC for transportation. Accordingly, a large percentage of the revenue collected in CMC is spent on waste disposal. Looking at this information, it is clear that CMC is facing a significant crisis in waste disposal. These include the lack of land for waste disposal, public protests when lands are available, transportation problems, and cost issues (Ramaesh, 2022). When asked about the suffering caused by waste in the responses received from the people living in CMC, 81% said they are suffering from waste somehow. 19% do not suffer from waste. These are high-income families living close to the city in the area. However, CMC people from low-income families respond that many suffer from waste.

There, they are mostly suffering from odours and various diseases. Here, most of the victims are suffering from short-term illnesses and some from long-term illnesses to some extent. As a percentage, 82% are susceptible to short-term illness and 18% to long-term illness. In addition, flies and mosquitoes, the destruction of water sources, disruption of urban aesthetics, and soil degradation are reasons for suffering. Here, in the respondents' opinion, they at least suffer from the damage caused by soil degradation.

Many of the respondents are not satisfied with the views expressed by the respondents regarding the waste disposal program through the Colombo Municipal Council. Further investigation revealed that the actions were not within a proper framework and in accordance with a policy. Here, 51% of respondents are unsatisfied with CMC's waste disposal. Accordingly, more than half of the respondents were dissatisfied with the disposal and collection of waste at CMC.

Various waste management methods have been adopted through CMC to avoid these problems, mainly using 4R methodology, compost production, and recycling centres. This is currently known as the flagship waste management process in CMC. However, this process is not going well. The reason 4R is not working properly is due to a lack of proper procedures and lack of public support. Although it is said that a large number of projects have been taken up for recycling, there are no reports of such projects. Although compost production has been successful, compost production is not done in CMC now. The main reasons are lack of space, people in Colombo not using fertilizer, outdated methods and a long process (Priya, 2022).

Looking at all this, it is clear that there is a gap between the CMC and the public regarding waste management. When asked about the existing waste management awareness, most respondents said they are aware of waste management. 90% have some understanding of waste management. 10% have never heard of it. Most of this 10% live in low-income families. Most respondents know about waste management through a media network or educational institution. This makes it difficult for the public to gain an understanding of the waste management that takes place within the CMC area. Awareness programs through CMC are mandatory for this. Only 43% have gained awareness through awareness programs conducted in CMC. The remaining 57% did not receive the notifications provided by CMC. That is a big problem. There is a gap in the waste management of the CMC and the public. According to the data collected, many people are interested in and learning about waste management. The information obtained from the respondents, a high percentage, like 96%, would like to know about this. Fewer than 4% do not like to pay attention to it. The main reason is to lead a busy life and not like it much.

They are interested in reuse. Due to economic difficulties, they are focused on getting the most out of a product during this time. However, there is less focus on this among high-income families. 50% of the respondents' compost products through waste. They use this fertilizer for their plants despite not growing it in large quantities. They have also benefited from it. Many people have benefited effectively from this waste management. Almost 90% of the respondents are willing to earn extra income by sorting and handing the waste to the waste management centres. Starting such a project will enable further resolution of the waste crisis. However, it is unfortunate that despite starting such a project, people are not even aware of the waste management centre at CMC.

Respondents believe that the measures taken to manage the waste in the CMC are inadequate. However, in 2021, the government laid a huge foundation for waste management. That is the establishment of a waste-to-energy plant. This is the latest method of waste management. It manages the waste in partnership with the Chinese company Aitken Spence. Here, the heat energy from the combustion of the collected waste is converted into electricity. This waste management process was first done in CMC in the Colombo District.

Thus, it is an excellent answer not only to the waste problem but also to the waste energy crisis, which is a big problem today. Due to the increasing population, this construction has been done as there is not enough space to dispose of the waste generated in the separate Colombo District. Today, the plant receives all the organic and non-recyclable waste collected in CMC. When the waste-to-energy plant cannot dispose of it, it will be disposed of at the Madampitiya landfill. The plant was initially scheduled to be built near the Aruwakkalu landfill but was halted due to the high cost of garbage disposal, as mentioned above. Subsequently, due to that problem, this project was first created in Kerawalapitiya. Here the collection and handover of waste are done through the private sector. The cost has been reduced as the waste in the Colombo Municipal Council is transported to the power plant by the private sector in their vehicles. Accordingly, the waste from all the districts except a few districts of CMC is collected by the private sector and delivered to the power plant.

Here, the waste received at the plant is stored in the waste pit for about 5 days, allowing the leachate to drain and waste to get fermented. The leachate is treated to produce clean water through a leachate treatment plant. After, the fermented waste is fed into the feeding hoppers through grab cranes, and the waste is burnt inside the moving grate incinerators to produce heat which is used to generate superheated steam in heat recovery steam boilers. Finally, the superheated high-pressure steam drives the steam turbine with a generator to produce electricity. The generated electricity is dispatched to the national grid through a transmission line. By-products are produced from the material that remains after power generation. Bottom ash is used as a substitute for sand and block stones in the construction industry. This process takes place every day.

The plant receives an average of about 700 MT of waste per day. CMC alone produces between 400MT and 450 MT. Most of the waste collected at this plant is through CMC. The plant has received about 230,000 metric tons of waste since its inception. On average, 800MT of waste can produce 10MWh of electricity. Accordingly, they generate 240MWh of electricity daily after being subjected to their operations. The amount of electricity added to the national electricity monthly is about 7GWh. Since its inception, about 100

GWh of electricity has been added to the national grid nationally. That is a significant increase.

This technology is still new to Sri Lanka. So technically, it has to be improved. Therefore, in the Waste-to-Energy power plant, continuous improvements are being made to improve the generation efficiency through new technologies. In addition, research and development work is being done to explore new technologies and dimensions for improvements. It does not generate electricity to repair machinery every 6 months. The repairs will take about a month. Waste will then be dumped at the Madampitiya waste dumping site, the only existing landfill at CMC.

On average, this process's monthly and annual cost is more than LKR 2 billion per annum. It is much money, but the benefits are enormous. The Waste-to-Energy plant provides full support to CMC for waste management. The future design of this waste-to-energy plant is Contributing to the country's socioeconomic development by recovering energy from waste, in line with the principles of circular economy, preferably by adding more capacity.

Accordingly, the launch of this concept to the whole of Sri Lanka will provide a sustainable solution to the ever-increasing waste and energy crisis. It will take Sri Lanka to become a prosperous country.

## Recommendation and Conclusion

### Recommendation

This provides recommendations for the best MSWM system in the CMC and for further development of this new technology. These recommendations are based on the findings of these studies. The environmental, social, economic, and health implications of evaluating and analyzing current MSWM practice are significant. The following recommendations are made.

To solve the current inefficiencies in the CMC's overall solid waste supply chain, it is essential to develop a systematic MSWM framework focusing on sustainability and the management hierarchy. Before incorporating the PPP (Public Private Partnership) approach, the existing SMW policy needs to be revised, and the CMC must formulate a specific policy, including details of cooperation with the various stakeholders. The formulated policies should be adequately implemented and not limited to a report. The energy generated

from these power plants can be further technologically developed to generate automotive fuels, cooking gas and high-capacity electricity.

The main problem with CMC is the lack of specific MSWM-related data and information. Further, a great deal of effort has to be put into obtaining that data. Research is beneficial in minimizing the weaknesses that exist in MSW. However, obtaining data to conduct such research would be challenging and would lose the ability to make the necessary recommendations to address those issues. Therefore, It is highly recommended that the CMC Office and the Institute conduct research and periodically collect and update data. Ensuring that the project meets international emission standards is essential. Emissions monitoring systems must be in place before the project can proceed, especially for burning alternative technologies. The public sector should intervene to monitor it. Especially the CEA. This may require changes in the legal framework.

A financial system that allows for the cost-covering operation of WtE power plants needs to be set up. That is, additional financial mechanisms must be applied. In addition to direct income from households through taxes and waste taxes, subsidies, gate fees, or nutrition charges for electricity can be included. The lack of experts in designing, operating and overseeing WtE power plants has profoundly affected MSWM. Therefore, the municipal staff of the Waste Management Authority and the power plant engineers should be allowed to enhance their knowledge and support the academic and scientific initiatives that nurture education in the field. Waste-to-Energy power plant currently uses the combustion technique. It is imperative to develop combustion techniques that are adapted to local conditions. Failure to do so will make it challenging to deal with future problems.

## Conclusion

The current solid waste management system of the Colombo Municipal Council is not fully systematic and still problematic. According to these rough conclusions, organic waste is generated in large quantities in this region. The collected waste is dumped at the Waste to Energy Power Plant and the Madampitiya Waste Dump. At present, the concept of reducing MSW volume and using it as a waste resource for power generation, a major crisis in Sri Lanka, is completely non-existent in the current MSW system. However, the

waste-to-energy power plant, which was created as a first step based on the CMC, can be identified as an existing successful project. Currently, the concept of Waste to Energy in Sri Lanka is used only for the Colombo District. Although solid waste management issues remain critical, this concept is a sustainable solution for SWM and energy crises. Currently, 240 MWh of electricity is added to the entire grid through waste-to-energy power plants. Sri Lanka currently produces electricity by burning organic, non-recyclable waste. In addition, this technology can potentially reduce the waste generated in Sri Lanka by more than 80%. In view of the above, it can be concluded from the special mention made in connection with CMC that Sri Lanka can prosper by converting the waste generated into Waste to Energy.

## Acknowledgment

We would like to thank the Colombo Municipal Council staff for their assistance in making this study a success.

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