ENERGY FROM WASTE: A SOLUTION FOR THE GARBAGE CRISIS AT MEETHOTAMULLA, KOLONNAWA, SRI LANKA

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ABSTRACT

Municipal Solid Waste (MSW) generation and management is a continually growing problem at global level, and is becoming more complicated day by day. Sri Lanka as a developing country also confronts the issue of increasing solid waste. Its major conventional solid waste management practice of open dumping is being challenged at present due to its negative impacts on environment and public health. Therefore, there is a necessity to look at this problem from a new perspective. Being identified the Energy from Waste (EfW) technologies as one of the best solutions to solve MSW problem, this paper aims at assessing the viability of setting up an EfW facility to get rid of Meethotamulla, Kolonnawa Garbage Mountain which has become a pressing issue today. The data gathered from secondary sources such as government publications, journal articles, newspaper articles, and other published reports intensifies this analysis. Based on the analysis, it is identified that mass combustion is the best possible technology to treat about 1300 tons of waste per day in order to make the Meethotamulla garbage site hazard free zone by 2040 and to generate 14MW of electricity per day as a by-product of waste combustion. And eventually, the PESTE analysis identifies the opportunities and threats that can be affected when implementing such a capital intensive facility.

Keywords: *Energy from Waste; Municipal Solid Waste; Meethotamulla Garbage Dump; Sri Lanka.*

1. INTRODUCTION

Current global Municipal Solid Waste (MSW) generation rates are expected to be increased steadily, challenging the environmental and public health management at global level. A recent estimation done by the World Bank (2012) reveals that world cities generate about 1.3 billion tonnes of solid waste per year at present, and estimates that this volume will be increased to 2.2 billion tonnes by 2025. The main causes to accelerate the generation rate of MSW are made known as increase of population, changes in life styles, rapid economic growth and rapid urbanization (Minghua *et al.*, 2009 cited in a Guerrero, Maas and Hogland, 2013).

Waste generation is unavoidable. The main issue associated with MSW in low-middle income countries, is inefficient collection and disposal which contributes to natural disasters such as flooding, erosion, air and water pollution and public health issues (The World Bank, 2012). Therefore, most of the countries have now begun to search for long term solutions to dispose of their solid waste in a proper and safe manner. With that, the interest for the concept of recovering Energy from Waste (EfW) has increased all over the world as a long term solution for waste management. In this concept, the waste is considered no more a waste but, as a renewable energy source (Rogoff and Screve, 2011).

Sri Lanka as a middle income country also confronts the issue of managing the increasing solid waste. The most common method of disposing waste still remains as open dumping (Bandara, 2011). Though it is a pressing issue impacted on the environment and public health, particularly in the most urbanized areas such as Colombo, Dehiwala-Mt Lavinia and Kandy, more than 95% of final waste are disposed in open dumps.

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When taking all districts of Sri Lanka into consideration, this is most grave in Colombo district where about 1500 tons of solid waste are collected and disposed in open dumps per day (Bandara, 2011 and Perera, 2003). Almost all these dumpsites are located in environmentally sensitive areas and in the vicinity of residential, commercial or institutional establishments. None of them have designed to minimize or control pollutants released from the decomposition of waste. Therefore, the high moisture content in the MSW have led to excessive leachate generation and produce methane about 72kg/t, causing numerous problems to the environment and public (Gunawardana *et al.* 2009 and Basnayake *et al.* ,2007). Further, exposing these dump sites to waste scavengers and insects such as mosquitoes, flies, etc., the surrounding residents face many health related issues, nuisance, air and water pollution (Gunawardana *et al.* 2009).

Though this issue has been curtailed to some extent by means of land filling, anaerobic digestion, composting and 3R concept, still the most common method of solid waste management remains to be open dumped in a more or less uncontrolled manner (Basnayake and Visvanathan, 2013 and Bandara, 2011). Therefore, the existing disposal sites in Colombo area have now become unmanageable with increased quantities of collected waste at present (Basnayake and Visvanathan, 2013).

Among approximately 58 garbage dumping sites in Colombo area, it was evidently identified that an immediate solution needs to be taken to treat Meethotamulla Garbage Mountain as it is almost filled to its capacity and more complains on various health hazards and frequent disasters such as flooding and explosions are being received by Kolonnawa Urban Council. It has turned out to be a common sight nowadays to see frequent protests organised by Kolonnawa general public against this dumping site. In view of that, this paper intends to identify the viability of implementing an EfW facility as a long term solution for waste management.

Accordingly, a desk study is presented in this paper. The data gathered from books, reports, paper articles, journal articles and other published documents on waste management in Sri Lanka as well as global and EfW technologies synthesises in order to identify the existing condition of the Meethotamulla garbage dump site, quantify the existing waste and the waste anticipated to be dumped at Meethotamulla garbage dump site, select an appropriate EfW technology and estimate the plant. Finally, the PESTE analysis identifies the external environmental impacts on implementing an EfW facility to treat this garbage dump.

2. FEASIBILITY STUDY

2.1. *INTRODUCTION TO MEETHOTAMULA GARBAGE DUMP SITE*

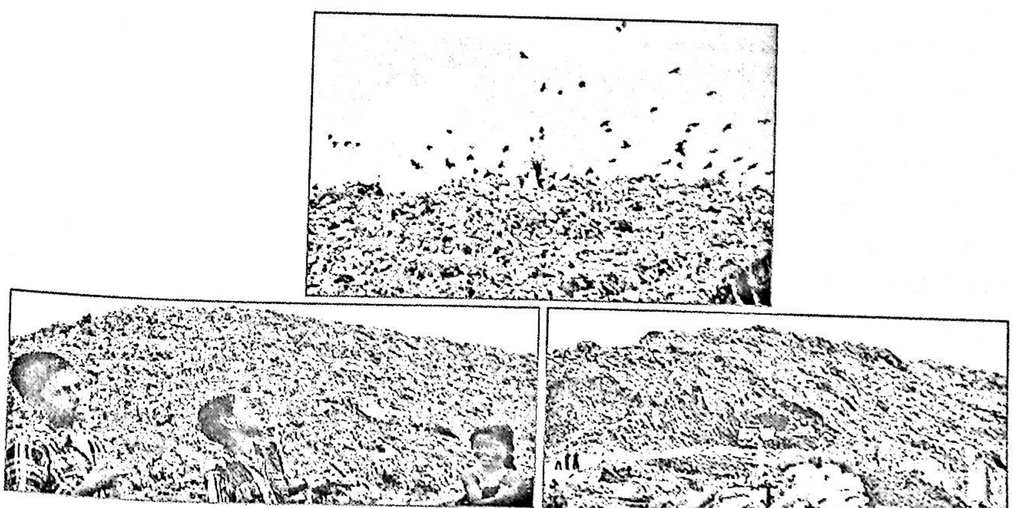

Figure 1: Meethotamulla Garbage Dump Site
Source: http://www.sundaytimes.lk/140706/news/authorities-promises-stink-as-much-as-garbage-mountain-105967.html

The Meethotamulla garbage dump site is located in Dahampura Grama Niladhari Division of Kolonnawa Divisional Secretariat Division in Colombo District of Western Province. The geological co-ordinates are: 6 0 56/ 6.4// N and 790 53/ 13.9//E. This has been existence for over 20 years and as shown in Figure 1, it spreads over 18-acre where 4700 families in eight villages live clustered around it. In addition to the residential places, three schools and few religious places are situated around it.

More than 50% of waste generated around Colombo and its suburbs are dumped by nearly 200 lorries in this site daily (Karunarathne, 2015). Though its capacity has almost exceeded, still the garbage is dumped there due to the lack of land filling sites. As a result, the residents of the surrounding area has become the worst victims of various environmental and health hazards. Residents have launched number of protests to draw the attention of relevant authorities to find a long term solution for the issues created by this garbage dumpsite.

Despite promises, none of the authorities have taken any action over the years to remove garbage from this site (Karunarathne, 2015). An interview conducted by Karunarathne (2015) with surrounding residents of this site reveals the following dreadful issues for which they seek immediate solutions.

- Haphazard dumping without a proper segregation process
- Unbearable stench which now has become part of their lives
- Breathing toxic air emitted from the waste
- Cracked houses as a result of the weight of the disposal and gas emissions from the rotting refuse
- Uncontrolled surface emissions of LFG into the air which contains carbon dioxide, methane, volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and odorous compounds that can adversely affect public health and the environment
- Crows and other birds flying around the garbage dump seeking food
- No clean water due to the contamination of ground water with waste leachates
- Most of the houses close to the canal often get flooded even after a brief shower
- 60% children in this area suffer from skin related diseases, respiratory problems and viral diseases
- The area is a breeding spot for rats, crows, cockroaches and other types of insects and reptiles

2.2. *Analysis of Waste Stream*

The initial sizing of an EfW plant is mainly depend on the volume of waste, its composition and energy content. Therefore, the main objective of this waste stream analysis is to estimate both the volume and composition of MSW that is currently being disposed and expected to be disposed in Meethotamulla garbage dump site in future.

It is to note that this analysis was carried out based on the data gathered through secondary researches due to the absence of a proper record keeping system on waste disposal.

2.2.1. *Quantifying the Waste Volume*

As it is identified in section 2.1, the age of the dump site is about 22 years for 2015, dump area is about 18 acres and height of the mountain is about 250 feet. Accordingly, it is estimated that the existing waste volume of this site is averagely 4,900,500 tonnes.

With the population growth in urban areas, Basnayake and Visvanathan (2013) estimates that the annual growth rate of waste generation in Sri Lanka as 1.2%. Further, the same authors reveal that about half (750 tonnes out of 1500 tonnes) of municipal waste generated from Colombo area are disposed in Meethotamulla garbage dump site daily. Based on this information, the expected waste quantity to be dumped at this site for next 25 years was calculated and is shown as in Figure 2.

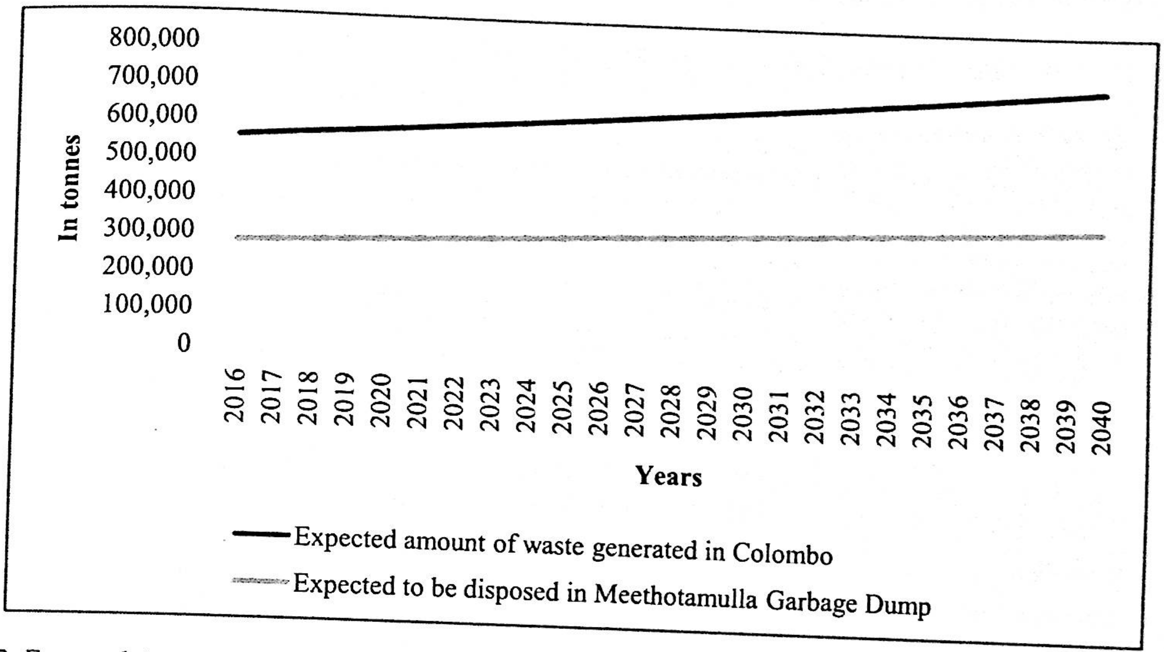

Figure 2: Expected Amount of Waste to be Generated in Colombo Area and Disposed in Meethoatmulla Garbage Dump

2.2.2. *Quantifying the Waste Volume*

A study done by Waste Management Authority - Western Province in 2010 provides a detail analysis of composition of waste generated from Colombo municipal area. According to that, 75% of total waste is biodegradable while other 25% distributes among plastic, rubber, glass, metal, e-waste and clinical waste.

The average moisture content of the MSW has been revealed as 40-45% (Waste Management Authority-Western Province, 2010) and as a result, Asian Productivity Organisation (2007) mentions that the calorific value is between 600 kcal/kg and 1200 kcal/kg in this waste. Therefore, it is considered 900kcal/kg as the average calorific value of the waste dispose in Meethotamulla garbage dump.

2.3. *Selection of Appropriate EfW Technology*

Reduction of the existing volume of waste mounted in Meethotamulla and simultaneously discontinuing dumping in this site mainly depends on the selection of an appropriate EfW technology. Accordingly, Table 1 summarises the results of the extensive analysis carried out in order to select the appropriate EfW technology for this particular case. Eventually it is selected "mass burning" over other EfW technologies as the most appropriate technology.

Table 1: Justifying the Selected Technology

Technology	Justification
Anaerobic Digestion Anaerobic digestion allows microorganisms to work on the feedstock available in a low temperature plant in order to recover carbon dioxide and methane that can be combusted to generate electricity, heat or bio fuel (Renewable Energy Association, 2011)	This technology is best suited for the treatment of wet organic waste such as, food waste, high moisture agricultural biomass and animal wastes including manure and domestic sewage (Renewable Energy Association, 2011). Therefore, it cannot be used as a MSW treatment method as it leaves all other waste materials except wet organic components which still requires disposal. Further, the waste dump in this particular site are not segregated, it may require additional strategies and resources to get sorted only the wet organics.

Gasification and Pyrolysis The waste transforms into energy without burning. Instead, the waste is heated to produce "syngas" which can be used to recover energy as steam, heat, electricity or bio fuel by creating a chemical reaction (Gasification Technologies Council, 2013).		Gasification and pyrolysis are suitable for substantial reduction in the total quantity of MSW after an extensive pre-treatment process. They are attractive alternatives for combustion. However, when comparing with combustion technology, thermal energy production in these systems is significantly low due to the reduction of the temperature of the residual heat in the steam (Murphy and McKeogh, 2004). Further, it's a more complex and an emerging technology with high capital and operating cost compared to the combustion (Belgiorno et al, 2003). In general, there is a very limited track record of commercial scale pyrolysis plant accepting municipal derived wastes in the world due to the problems related to tarring. The deposition of tars cause blockages and other operational challenges associated with plant failures and inefficiencies (DEFRA,2013) Therefore, Sri Lanka as a country which suffers from lack of institutional capacities and financial support for solid waste management projects (Vidanaarachchi et al, 2005), this technology would not be the best option.
Combustion Combustion is the most dominant EfW technology which uses widely due to its simplicity and relatively low capital cost (Themelis, 2003). It is functioned in an Energy from Waste (EfW) plant, in which the waste is burned at 1000 ^{0}C and recover steam, heat or electricity as energy. The most common methods used to combust solid waste are mass burning, modular combustion, fluidized bed and refuse derived fuel (RDF). Among them, the two most widely used and technically proven technologies are mass-burning, and modular combustion. Fluidized-bed and refuse-derived-fuel combustion technologies have been used to a lesser extent (United Nations Environment Programme, 1996).During the last 30 years of period, the development of EfW facilities have increased significantly and there are about1300 combusting EfW facilities worldwide (Rogoff and Screve, 2011).	RDF Burn	In this method, all waste is sent through a pre-treatment process prior the combustion. It is removed all non-combustibles such as metals, glass, rock, concrete, and sheet rock and hazardous materials. With this minimal sorting, it has the capability of getting a high average calorific values and achieving higher energy content. The ash production and the GHG emission is lower than in mass burn mode (EnviroPower Renewable Inc, 2013). Further, an extra income can be earned by selling sorted recyclable and non-combustible materials. Although RDF processing gives the above advantages, its complexity has increased the operating and maintenance costs and reduced the reliability of RDF production facilities around the world (UNEP, 1996). UNEP (1996) further mentions that capital costs per ton of RDF combustion are higher than mass burning. Therefore, this technology is also set aside for the same reason of disqualifying gasification and pyrolysis technologies.
	Mass Burning	Mass burning is the predominant and simplest method of combusting waste to generate energy (Hasselriis and Mahoney, 2013). This is one of the best technologies to reduce the volume of waste too. In this technology, all types of MSW are burnt as received, after the removal of hazardous and non-combustible materials such as metal and glass. Therefore, it requires less labor power for sorting, so that it is cost effective (EnviroPower Renewable Inc, 2013). When comparing with gasification and RDF technologies, mass burning is a simple process with affordable capital and operation cost. Though it has a high impact to the atmosphere through emission of greenhouse gases, it can be reduced by using an extensive flue treatment system. Further, it is identified, mass burning process generates high volume of ash (Hasselriis and Mahoney, 2013). However, they can be used in making eco bricks or in concrete mixtures. Thus, in consideration of simplicity, affordable capital and operation cost and disposition of by-products, mass burning would be the suitable technology for handling waste in Meethotamulla garbage dump.

2.4. *PLANT CAPACITY AND ITS POWER GENERATION CAPACITY*

It is to note that the estimation of plant capacity is based on the plant life time of 25 years. It is assumed that the first four years (2016-2019) of the project life cycle will be taken for the preparation and implementation and then the facility will be operated from the 05th year for 21 years ahead (2020-2040).

Considering both existing and expected waste as calculated in section 5.2.3, it is assessed that there is a waste volume of 4,900,500 tons already in the dump site and expected to be dumped during the 2016-2019 period of facility preparation as 1,127,226 tons. Accordingly, there is a total amount of 6,027,726 tons. Among them, it is assumed only 65% of waste can be used for the EfW process, while 30% is set aside as almost composted in the dump it self and remaining 5% is put aside as non-combustible materials.

The expected waste quantity to be dumped during plant operation period (2020-2040) is estimated as 6,894,029. It is assumed that only 90% can be used for the EfW process, while 10% is set aside as non-combustible materials.

Based on above data and assumptions, the amount of waste that can be combusted daily from year 2020 is calculated as follows.

Waste from Meethotamulla	= (4,900,500 + 1,127,226) *0.65/ (21*365)	(Eq: 01)
Garbage Dump	= approximately 510 tons/day	
Waste from daily collection	= 6,894,029 * 0.9/ (21*365)	(Eq: 02)
(From 2020)	= Approximately 800 tons/day	

Accordingly, the facility has to be designed to process average 510 tons per day from exiting volume in Meethotamulla garbage dump and 800 tons per day from daily collection from Colombo area from 2020. Eventually, it requires to treat averagely 1300 tons of waste per day. Thus, the plant capacity is estimated as 1300tons/day

With the identification of daily combustible solid waste quantity and net calorific value, net power generation capacity of the plant is estimated as 14MW as in Eq: 03.

Total combustible solid waste quantity (W)	= 1300 tons/day	(Eq: 03)
Net calorific Value (NCV)	= 900kcal/kg	
Energy Recovery Potential (kWh)	= W x NCV x (4.184 x 1000 /3600)	
	= 1,359,800 kWh	
Power Generation Potential	= 1,359,800 /24	
	= 56,658 kW	

When producing electrical power only, World Bank mentions that (1999) it is possible to recover up to 35% of the available energy in the waste as power. Therefore, it was considered the conversion efficiency of waste collected from Colombo as 25%.

Thus, total net power generation per day of operation is estimated as 14 MW

3. PESTE ANALYSIS

With the identification of appropriate EfW technology, plant capacity and its net power generation capacity, PESTE (Political, Economic, Social, Technological, Legal and Environment) analysis identifies the opportunities and threats that can be considered prior making strategic decisions on implementing an EfW facility for this particular case.

3.1. *POLITICAL*

- Sri Lanka is a developing country which still has an unstable political condition and less political commitment on developing public infrastructure projects.
- There is no provision for energy recovery from waste in existing national waste management strategy, other than avoidance, reduction, reuse, recycling, and final disposal. Therefore, it may take considerable time to convince the advantages of this kind of a project to Sri Lanka.
- Though, the National Energy Policy 2006 has identified municipal solid waste as a renewable energy source and a Feed in Tariff has been introduced to be effected from year 2012, there is no an incentive or subsidy scheme to encourage investors to invest in EfW facilities.

3.2. *ECONOMIC*

- This is a capital intensive project.
- Generally, waste incineration experts mention that it is required to have an incinerator that burns at least 1000 tonnes of garbage each day to have an economically viable operation (Alternative Energy news, 2006). In view of that, this proposed plant possibly will make an economically viable operation by burning 1200 tonnes every day.
- This kind of a project will contribute to the local economy by creating both direct and in-direct employment opportunities in the form of officers, operators, technicians, labourers, and drivers.
- The main income source of this plant is selling electricity to the national grid. If it operates without major failures throughout its lifetime, it would be a profitable investment.
- Selling scrap metal and bottom ash will also create a considerable income from the project.

3.3. *SOCIAL*

- The proposed project will help to make the Meethotamulla garbage dump site as hazard free zone by 2040.
- It will cause to improve the local sanitisation by eliminating harmful fauna such as mosquitoes, flies, rats, cockroaches and other disease-causing vectors.
- No more bad odours will generate from the decomposition of organic waste in the dump.
- Further, the negative impacts such as frequent disasters (floods and explosions), ground water contamination with leachate, emission of toxic gases to the atmosphere and spoiling of the quality of soil due to leaching of salts and heavy metals will be nullified.
- The project will be a real example to increase the awareness on EfW facilities, so it will cause to widen the EfW plants throughout the country as a long term waste management strategy.
- In general, it is unavoidable the oppositions raised from the public and environmental organisations regarding this kind of an infrastructure project in Sri Lanka. Therefore, necessary actions have to be planned at the initial stage to face them.

3.4. *TECHNICAL*

- Generating energy from waste combustion is not a proven technology in Sri Lanka yet.
- Therefore, the project will lead to share and transfer the technical knowledge and the technology between Sri Lanka and other countries from where the equipment are imported.

3.5. *LEGAL*

- Compliance with all statutory requirements is highly essential prior setting up the project.
- However, the approval process possibly will take considerable time due to the poor coordination among relevant government agencies such as Central Environmental Authority, Sustainable Energy Authority Sri Lanka, Ministry of Mahaweli Development and Environment and Ceylon Electricity Board.

3.6. *ENVIRONMENTAL*

- This is an eco-friendly project which generates electricity using a clean energy source.
- It will reduce the amount of garbage piled in the Meethotamulla dump site and avoid methane emissions from the site.
- This will further help in reducing the future need of open landfill sites and decreasing the disasters and health hazards associated with them.
- However, it requires an effective air emission control system to avoid emitting harmful pollutants to the air generated through waste combustion.

4. SUMMARY

The aim of this paper was assessing the viability of setting up and EfW facility to get rid of Meethotamulla, Kolonnawa Garbage Mountain which has become a pressing issue. After a comprehensive analysis of several EfW technologies, it was identified "mass combustion technology" as the best possible option to reduce the waste heaped in Meethotamulla garbage dump. Based on the waste stream analysis, it expects to treat about 1300 tons of waste per day in order to make that garbage site hazard free zone by 2040 and it is anticipated to generate 14MW of electricity per day as a by-product of waste combustion. The PESTE analysis carried out on political, economic, social, technological, legal and environmental aspects identified that this project has a considerable capacity to contribute to local economy by managing solid waste to a certain extent, generating electricity from clean energy source and creating more job opportunities for the locals.

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