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Sustainable Approaches to the Municipal Solid Waste Management in Sri Lanka

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Abstract: Municipal solid waste (MSW) is a serious environmental & socioeconomic issue in Sri Lanka and Haphazard disposal, population growth, migration and rapid urbanization will accelerates the issue further. Comprehensive and accurate measurement of waste generation and disposal continues to be an issue at national, provincial and local levels. The present composition of solid waste collection by the Municipal Councils 49.5% (1,696 Mt), Urban Councils 17.4% (594.5 Mt) and "Pradesiya Saba" Areas 33.1% (1,133 Mt). Conversely, through the several government and non- government projects were operating towards the National Solid Waste Management (NSWM). Further they were have been conducted the analyses for their internal use. However, there is no proper mechanism to coordinate this information and research, or to compile results with an intergraded approach. Appropriate estimations and evolutionary predictions will sustain new projects by minimizing difficulties. Previous data were shows approximately MSW is contain 50 - 65% readily bio-degradable waste or organic component and the balance is inorganic component. Low calorific values recoded in organic fraction of waste and it is possible to use as raw material of composting or bio-gas generation. And the receiving part of the waste should be running through the material recovery facility (MRF) and the residue has to incinerations and finally to landfilling. With the current situation there is a possibility of earning 20-22 US$ from a one metric ton of mixed MSW. There is no proper focus into the Cleaner Development Mechanism (CDM) to the current MSW management project as well as there is no focused in to Intergraded Solid Waste Management (ISWM) in the country. This paper suggested that the importance of ISWM by maintaining a sustainable composite mechanism through locally – available materials and expertise, with evidence based approach planning and strategy through eliminating the potential risks to provide a clean, healthy pleasant living environment and resource management culture for current and future generations of Sri Lanka.

Keywords: Municipal Solid Waste, Intergraded solid waste management, Material recovery facility, Cleaner Development Mechanism, locally – available materials and expertise.

1.0 Introduction

The Democratic Socialist Republic of Sri Lanka is an island in the Indian Ocean southwest of the Bay of Bengal, between latitudes 5° and 10°N, and longitudes 79° and 82°E.It is separated from the Indian subcontinent by the Gulf of Mannar and Palk Strait, It is located at the global logistic hub by intercepting with the major air and sea routes between Europe and the Far East. Sri Lanka has land area of 65,610 sq.km. and Population density of 331 per sq.km. The population growth rate was 0.9% in 2014 with respect to statistical data sheet 2015[1]. It has 25 administrative districts and 9 provinces Country economy worth $80.591 billion (2015), ($233.637 billion PPP estimate) and a per capita GDP of about $11,068.996 (PPP)[3].And Gross National Production (GNP) at current prices Rs.Mn. 9,544,608[1]. The country main industries were processing of rubber, tea, coconuts, tobacco and other agricultural commodities; telecommunications, insurance, banking; tourism, shipping; clothing, textiles; cement, petroleum refining, information technology services and construction.

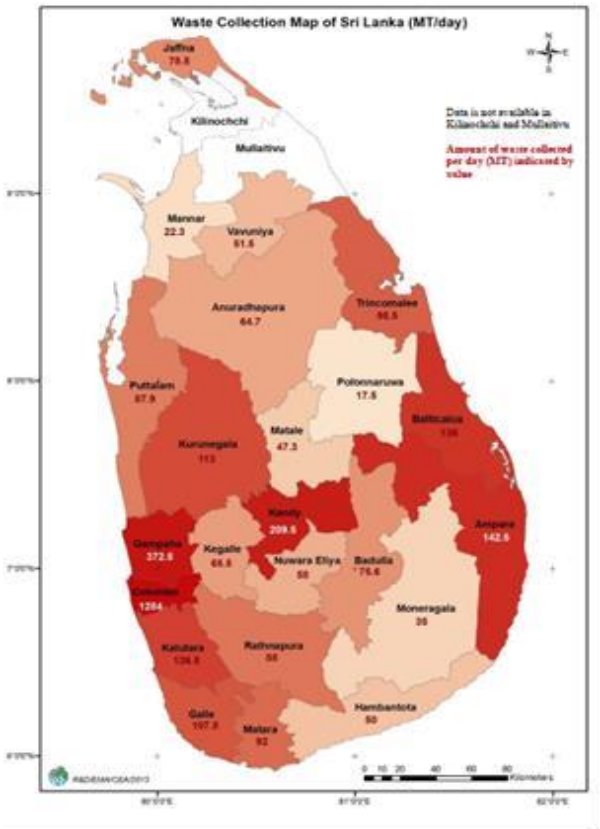


Figure **1:** Waste Collection Map of Sri Lanka
Source: Database of Solid Waste in Sri Lanka, "*Pilisaru*" *National Solid Waste Management Programme, CEA, 2012*

Municipal solid waste (MSW) is a serious issue in Sri Lanka and Haphazard disposal of Solid waste accelerates the serious environmental & socioeconomic issue further. It is a well-known fact that the waste generation has been increased due to the development, population growth, rapid urbanization, migration and accompanying changes in the consumption pattern and industrialization.

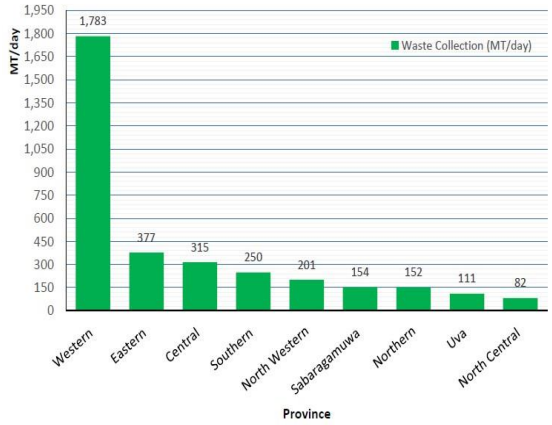
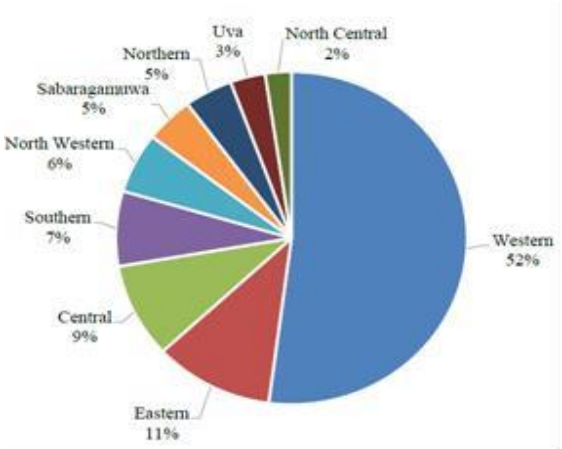


Figure 2: Waste collection provincial wise
Source: Database of Solid Waste in Sri Lanka, "Pilisaru" National Solid Waste Management Programme, CEA,

With available statistics on MSW Comprehensive and accurate measurement of waste generation and disposal continues to be an issue at national, provincial and local levels. Daily 3,242 Metric tons (Figure1, 2) were collected by the Local Authorities and the highest amount of 1,783 metric ton was collected daily by Western province (Figure2). The highset population reported from Colombo District which collects 1,284 metric tons solid waste(Figure1). The composition of solid waste collection by the Municipal Councils 49.5% (1,696 Mt), Urban Councils 17.4% (594.5 Mt) and Pradesiya Saba Areas 33.1 % (1,133 Mt). (Figure3) [4]



2012

Figure 3: Waste collection percentages
Source: Database of Solid Waste in Sri Lanka, "Pilisaru" National Solid Waste Management Programme, CEA,2012

The compositions of solid waste are mainly Polythene/plastic waste/Shopping bags, Short term bio-degradable waste (animal & *plant matter*), Long term bio-degradable waste (*e.g. Coconut shells, King Coconut shells, .etc.*), Metal waste, Wood waste (including *tree cuttings*), Glass waste, Paper wastes, Building waste, Slaughter house waste, Cloth/garment waste, Hazardous waste (*batteries, CFL bulbs, e-waste,….etc.*) and other waste (*e.g. industrial waste and other*) (Figure5) [4,7,14].54.5% is short term bio-degradable waste and 10.5% is the polythene/plastic waste/shopping bags and it was the second largest category in MSW(Figure4).[4,7,14].With the statistics of Solid Waste Management in Sri Lanka total of 11,695 employees were involved. From those 10,196(87%) were owned by Local Authority and 1,499(13%) are owned by private sector.

Expenditure on solid waste from the Local Authorities in Sri Lanka is about US$ 27 million [4].

Presently in most part of the country MSW collected and typically end up in open dumps and open burning as a primary method, and in some cases are deposited in illegal dumping sites. Meanwhile, Sri Lanka will practise the conventional waste management procedure and it focuses largely on waste collection, treatment and disposal. With respect to the characteristics of MSW, operational & maintenance cost, marketability of final product, public perception, technical & financial affordability are the factors that leads to the selection of proper solid waste management program.

Only limited attempts are made to adopt Integrated Solid Waste Management (ISWM) practices that involve waste reduction at the source, resource recovery and recycling.

There are several government programs such as "Pilisaru" National Solid Waste Management Programme 'Towards garbage free Sri Lanka by 2012'; with the meaning of the "Pilisaru" was regaining the usefulness. It is allocated approximately 5 billion rupees for the "Pilisaru" programme, through the 2008 national budget of Sri Lanka [4]. However, it is a challenge and very difficult task to provide technology, infrastructure, legal advice and political leadership. Furthermore, it is very difficult to change the long established habits & attitude of people.

2.0 Composition of Municipal Solid Waste

The Sri Lankan MSW mostly consists of Short term 54.5% bio-degradable waste (i.e. Food/Kitchen Waste, animal & plant matter…etc.), Long term bio-degradable waste (5.9%) (E.g. coconut & king coconut shells, rice husks, slaughter house waste (2.8%), leather …etc.) And Non-biodegradable as such; Polythene/soft & hard plastics waste/shopping bags (10.5%), Metal waste (1.8%) (E.g. aluminium cans, steel containers…etc.), Wooden waste (e.g. show dust, tree cuttings…etc.), Paper & cardboard waste (3.7%), cloth/garment waste (1.2%), Glass waste (3.1%), Building construction waste, hazardous waste (0.4%) (Batteries, CFL bulb, paint bottles, e-waste…etc.) and other waste (7.7%) (e.g., Industrial waste …etc.) [4] (Figure 5).

Figure 4: Waste Compositions Survey
Source: Waste characteristic survey, Kunhwa Engineering & Consulting Co.Ltd.

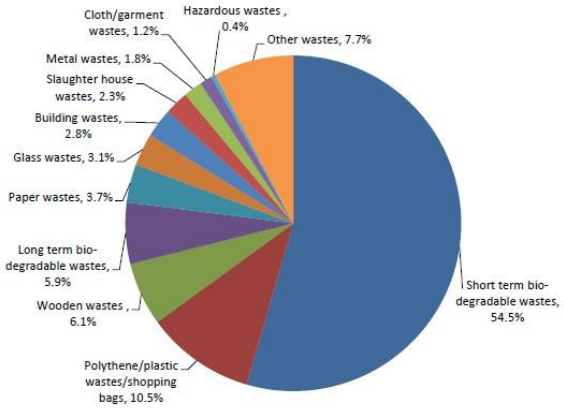


Figure 5: Compositions of MSW in Sri Lanka
Source: Database of Solid Waste in Sri Lanka, "Pilisaru" National Solid Waste Management Programme, CEA, 2012

3.0 Waste separation mechanism.

Presently most of the local authorities, there is no proper mechanism to segregate the waste at the source. The generated waste from residential, commercial…etc. are stored at polythene/polybag. Sometimes this bags will collect after 2-3 days which started the inside degradation. This will create many issues for composting/other methods as such leachate, bad odour…etc. Presently considerably good level of segregation at the source and proper waste collection mechanism was practised by several Local Authorities like, Balangoda & Kalutara Urban Councils. However most of the local

authorities will collect unsegregated waste from the source.

Figure 6: Pikers in clean MRF/Waste sorting belts

3.1 Material Recovery Facility (MRF)

Through the material recovery facility it will facilitate to recover the recycles especially polythene, glass, rubber, metals…etc. (Figure6, 7). Presently in Sri Lanka MRF will basically consist of an elevated unloading area conjunction with a ramp and a conveyer belt and it will facilitate manual separation of waste (Figure7, 6).

Figure 7: Some existing MRF in Sri Lanka

There are several methods such as; jigs (device that separate less dense to more dense particles by using the difference in their abilities to penetrate a shaken bed) (Figure7), Air Classifiers (is to separate less dense, mostly organic materials from the more dense, mostly organic fraction using air as the fluid)
(Figure8,9) [6].

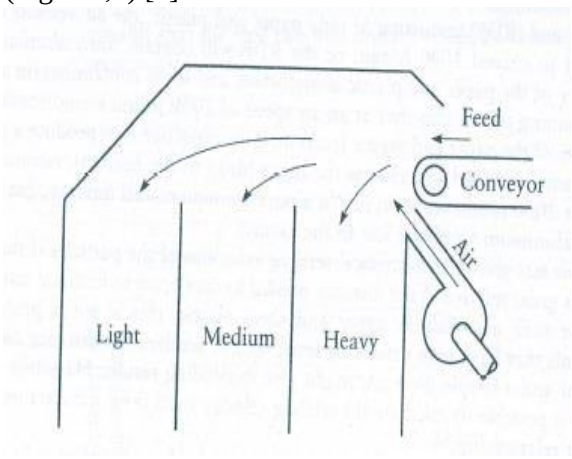


Figure 8: Horizontal Air knife:
Source: Solid Waste Engineering", Brooks/Cole,511, Forest Lodge Road, Pacific Grove, CA

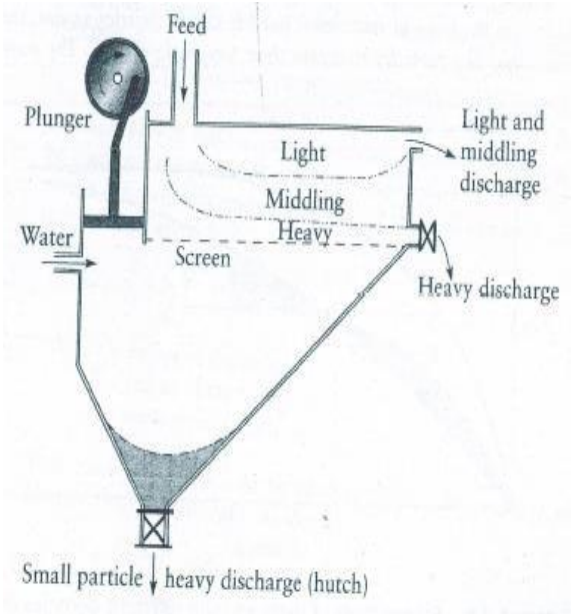


Figure 9 : Common plunger
Source: Solid Waste Engineering", Brooks/Cole,511, Forest Lodge Road, Pacific Grove, CA

Incorporate the waste separation mechanism to achieve the sustainability. Waste separation mechanism; open the waste containers/ waste bags at the starting point open the bags and segregate to bio degradable and non-biodegradable

(Polythene, plastic, glass, metals…etc.) then segregate the hazards waste(batteries, CFL bulbs…etc.) at the initial feedstock. And finally recover the plastic, metals, glass) (Figure7)

4.0 Option for Bio-Degradable Waste 4.1 Composting

Sri Lankan context approximately MSW is contain 50 - 65% readily bio-degradable waste or organic component (Figure5)[4,7,14]. Therefore converting this higher percentage portion into compost/soil conditioner will be environmental sound practice as well as economically viable option for an agricultural country like Sri Lanka [2]. It is a biological process which happens under the controlled condition of aeration, carbon nitrogen ratio, temperature and moisture. Different technological approaches to produce compost as such passive composting system, windrow composting system aerated pile system and in the vessel system[6]. From those passive aerated open windrow system (Figure10) is more feasible for the country like Sri Lanka [15]. Composting process will reduce the volume of raw waste of MSW more than 60% of its initial volume [15]. Composting of MSW will help to decrease the considerable amount of waste that must be sending to final landfilling.

Figure 10: Some existing composting plants in Sri Lanka

Quality Composting is free from methane generation, unpleasant odours, easy to handle, can be stored for a long time and it has wide variety of uses in agriculture [15]. Quality compost will improve physical properties, chemical properties, biological properties, adds organic matter, varying amounts of soil nutrients such as nitrogen, phosphorous, potassium...etc. It also improves soli structure, aeration and moisture content of soil. It also suppresses certain plant diseases and parasites and kills weed seeds thereby controlling weeds & diseases. With a comparison with chemical fertilizers compost will increase agricultural production rate. Composting has main role in organic farming which is the fairly growing industry in Sri Lanka. The demand will be increased for compost as well as organic farming products in bout local & export market.

Figure 11: Residual Composition Study of Compost

Source: Waste characteristic survey, Kunhwa Engineering & Consulting Co.Ltd.

Approximately production cost was US$ 26-30 per metric ton in Sri Lanka and wholesale price US$ 76-91 per metric ton (Table 1). Therefore it will give approximately 67% profit with composting of MSW. Area requirement for composting project is approximately 11.5 Perch/MT. Therefore composting is an attractive financial alternative and as well as value added opportunity.

4.2 Bio-Gas Generation

Readily bio-degradable component such as food waste, agricultural waste, animal dung, vegetable & fruit waste…etc. can be used as a biogas fuel generation [6]. It is produced during the anaerobic decomposition of these waste materials and contains 60% of methane composition. The generated bio gas can be used for cooking, lighting, also in conventional vehicles and also be burned in a generator to produce electricity [5,6].

Biogas Energy Systems is anaerobic digesters that create system-wide operational efficiencies in energy production and operational costs [6]. While the amount of methane that can be produced from a given feedstock is relatively fixed (Figure 12), system-wide facility design can optimize methane production and power generation [6]. With the features of redundancy, gas storage, flexibility, and disaster prevention will give more Biogas Energy Systems the ability to produce more energy from a given substrate.

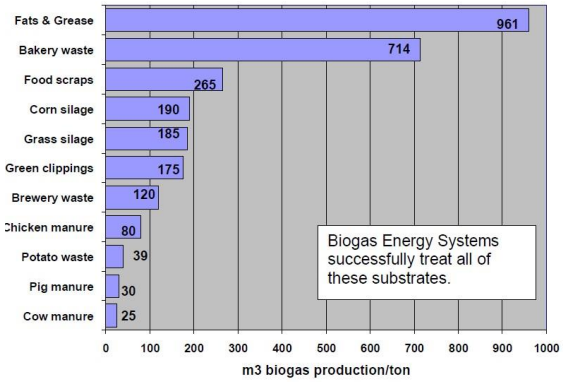


Figure 12: 1 m^3 Bio gas production /ton
Source: Basisdaten Biogas Deutchland, Marz 2005: Fachagenture Nachwachsende Rohstoffe e.v.

Countries like Germany, where more than two thousand anaerobic digesters operate, biogas production has undergone decades of continual quality improvement. They use most of them for energy production and they demand the highest efficiencies [16]. Sri Lanka is practising two type of biogas reactors (Figure 14), the Dry Batch System and the Continuous System [5]. The process of anaerobic digestion consists of three steps of Decomposition (hydrolysis or plant of animal matter. the step breaks down the organic material to usable-sized molecules like sugar), Conversion of decomposed matter to organic acids and Conversion of acids to methane gas.

Figure 13: Bio Gas Plant Dikkovita, Sri Lanka

Biogas Energy is dedicated to bringing with mature anaerobic digestion technology to easily biodegradable waste in MSW Sri Lanka and to achieving good levels of energy production with answering to the country energy requirement. As well as effective Bio-gas generation (Figure 15) will provide superior value and efficiency over the lifetime of the project.

Figure 14: Landfill Gas liquefaction Hartland unit located in Victoria, B.C. developed by CryFuels System, Inc.
Source: CryFuels Systems

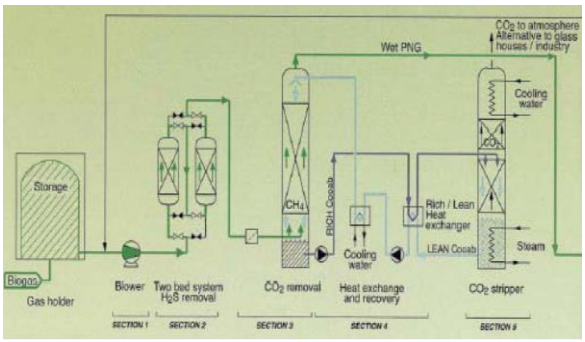


Figure 15: Effective Bio-gas generation
Source: Cirmac, undated

4.3 Animal/Poultry Food Generation

The municipal solid waste contains approximately 20 – 30 % of food waste & slaughterhouse which can be used as animal / Poultry /fish foods. This will be generated from mainly from restaurants, hotels, fish markets, supermarkets, expired foods, food & meat processing industries …etc. [17]. The waste should collect with in 12hrs/ before rotten and freeze and used for animal food processing. Countries like Korea and Japan practice in vast range and convert their waste as a value added product. The systems will be relying on more

technical & financial inputs, but this will be reducing the huge amount of bio-degradable component in MSW in an economical manner.

5.0 Option for Inorganic/Non-bio- degradable Waste 5.1 Application of 3R Concept

Solid Waste Management in Local Authorities application of 3Rs will strive to reconfigure the systems to deliver better returns on natural, human and economical investments, within the same time reducing GHGs, extraction and using rare natural resources by creating less waste and reducing social disparities with promoting reusing and recycling. Recycling entered the mainstream of solid waste management from the histories by the underfunded, haulers / idealistic individuals. Nevertheless, rather multinational & national garbage companies are now involved in recycling, regardless of the price paid for recycle material, could be profitable (Table 1). While some long for the days of the idealistic recycler, no one can dispute that more material is being recycled today. Recycling business will create direct and indirect "green job" opportunities in various cross sections of the society. Reducing generation, promoting reuse and recycling of waste will reflects the balance of environmental conservation and economic growth through an effective use of virgin resources (Figure 16).

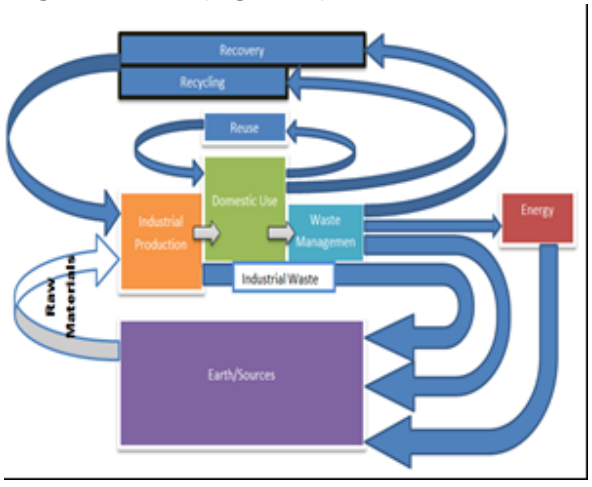


Figure 16: Resource flow through in a resource management infrastructure

5.2 Combustion/Incineration

Much of the MSW is combustible (approximately 95% of composting residue/ other residue) [7] and the destruction of this fraction can coupled with the recovery of energy as an option in solid waste management .Refuse can be burned as it is or it can be processed to improve heat value and to make it easier to handle in combustor/incinerator (Figure 17, 18). Processed refuse can also be combined with other fuels, such as coal, and cofired in a heat recovery combustor/incinerator.

MSW residues are contains 80-90% combustible materials [7]. The lower calorific value of MSW is reported 6845.77 kj/kg (1637.74 kcal/kg) [8]. Therefore from the other hand, MSW is not an insignificant source of power. However, when concerning on other effects Green House Gas emission, Water pollution, Land Pollution, eyesore and other socio economic concerns the proper combustion/incineration (Figure 17, 18) was a better solution for the residue of the Sri Lankan MSW.

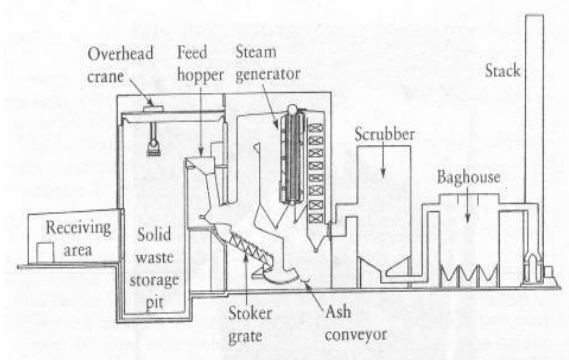


Figure 17 : A typical municipal combustor**:**
Source: Solid Waste Engineering", Brooks/Cole, 511, Forest Lodge Road, Pacific Grove, CA

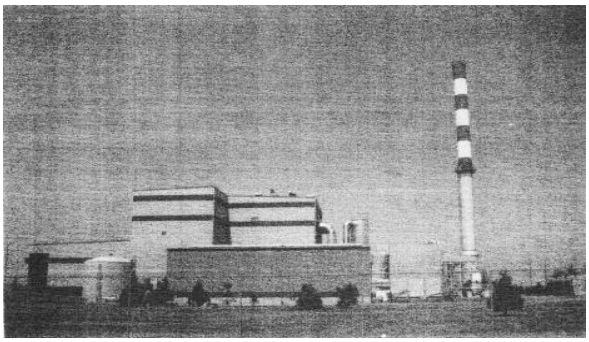


Figure 18: A typical municipal combustor
Source: Solid Waste Engineering", Brooks/Cole, 511, Forest Lodge Road, Pacific Grove, CA

From the controlled or proper combustion/ incineration ash will reduce the capacity of the sanitary landfill with a density of 3300 lb/yd^3 at this density the ash is highly impermeable, with a permeability as low as 1X 10^{-9} cm/sec[6]. Therefore land fill value will be increased compared to the other sanitary landfills. Further some of the ash include to Road base material, Structural fill, gravel drainage ditches, capping strip mines and mixing with cement to make building blocks [6].

6.0 Intergraded Solid Waste Management (ISWM)

Intergraded Solid Waste Management is a comprehensive waste prevention, recycling, composting and disposal programme (Figure 19) [9]. It will be consider how to prevent, recycling and manage solid waste in an effective way to protect human health and the environment (Figure 19). The ISWM involves evaluating local condition and requirements, through that selecting and combining the most appropriate waste management activity efficiently.

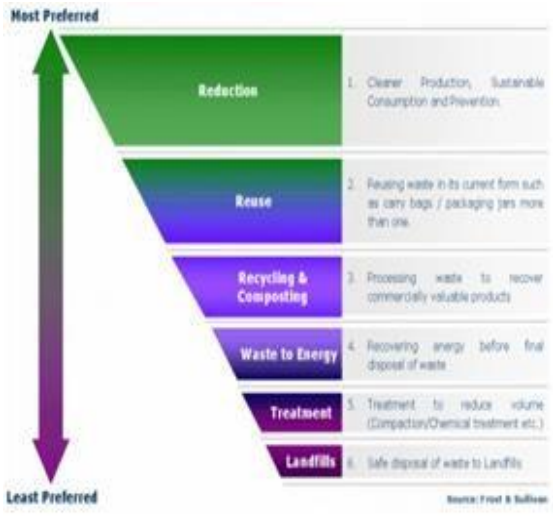


Figure 19: Integrated Waste Management Hierarchy
Source:http://www.frost.com/prod/servlet/cio/186567195

7.0 Cleaner Development Mechanism (CDM) to Solid Waste Management

The Clean Development Mechanism (CDM) is one of the Flexible Mechanisms defined in the Kyoto Protocol (IPCC, 2007) that provides for emissions reduction projects which generate Certified Emission Reduction units (Figure 20) which may be traded in emissions trading schemes [11].It is defined in Article 12 of the Kyoto Protocol and is planned to meet two objectives. First is to assist parties contributing to prevent dangerous climate change which is the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) and assist to parties achieving compliance with Certified Emission Reduction units of greenhouse gas (GHG) emission reduction projects under the Kyoto Protocol [12].

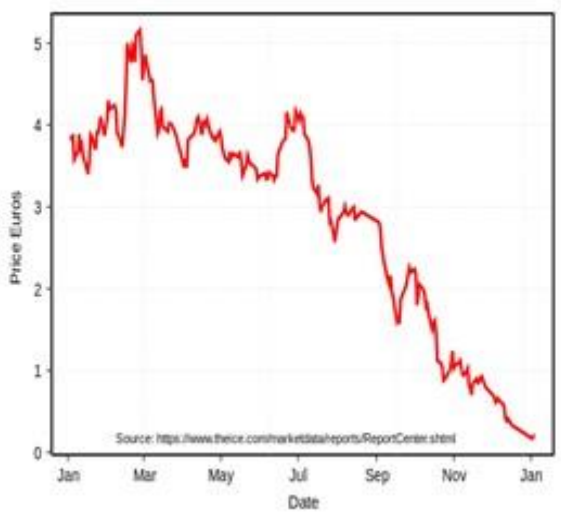


Figure 20: Certified emission reduction spot prices 2012

Source:https://en.wikipedia.org/wiki/Clean_Development_Mechanism

India generates the MSW approximately 40 million tons per Through the CDM Indian market is more cornered certified emission reduction (CERs) and dominance in carbon trading. India Inc. pocketed Indian Rupees 1,500 crores in the in the year 2005 just by selling carbon credits to developed-country clients [13].

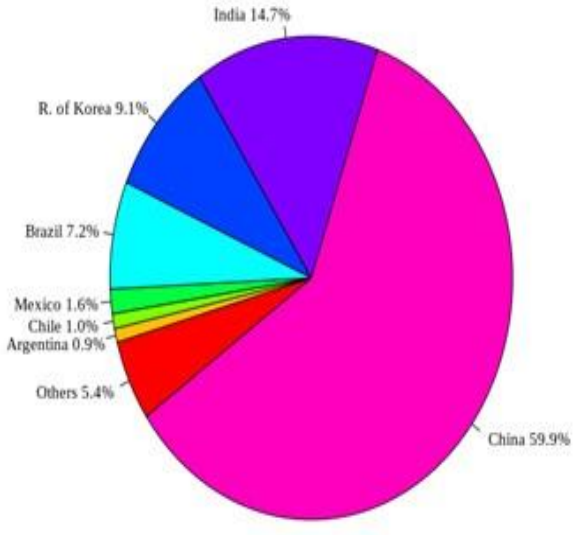


Figure 21: Certified emission reduction units by country

Source:https://cmd.unfccc.int/statistics/Issuarance/CERIssuedbyHostPartyPieChart.html

Table 1: Economical aspect of the current Solid waste Management in Sri Lanka.

Recoverable waste Type from a Mt		Consumable from recovered 90% (Kg/Day)	Total collection per month (Kg)	Unit price / Kg	expected income per month (SLR)
Composting	100% segregated Waste	180	5400	8	43,200.00
	Unsegregated waste	90	2700	10	27,000.00
Polythene	White	3.06	91.8	35	3,213.00
	Shopping	4.59	137.7	6	826.20
	Other	7.65	229.5	5	1,147.50
Plastic	PET	0.54	16.2	48	777.60
	Unusable	0.18	5.4	0	-
	Mixed Plastic	1.08	32.4	35	1,134.00
Paper & Card Board	News Paper	1.683	50.49	8	403.92
	Card Board	3.366	100.98	12.5	1,262.25
	Unusable	11.781	353.43	0	-
Coconut Shells		3.6	108	13.25	1,431.00
Glass	White	1.89	56.7	4.75	269.33
	Color	0.675	20.25	2.75	55.69
Metal	scrap iron	0.108	3.24	40	129.60
	tin & cans	0.432	12.96	18	233.28
Total Expected income from 1 Mt of MSW per month					**81,083.36**
Total Expected income from 1 Mt of MSW per Day					**2,702.78**

7.0 Discussion

Municipal Solid Waste (MSW) is a serious environmental & socioeconomic in Sri Lanka and

Haphazard disposal of Solid waste , rapidly increasing quantities and diverse characteristics of waste will accelerated, it further. Local authorities are running with a financial & technical burden for waste management as well as pressure on landfill requirements.
Hence, in most part of the country MSW collected and typically end up in open dumps and open burning as a primary method, and in some cases deposited in illegal dumping sites. As a result, massive garbage dumps such as the 'Bloemendhal" road eyesore. Furthermore urban air/water pollution, floods induced by solid waste clogging in drainage canals and land degradation, as well as the concerns of the risk to the public health and its translation into economic costs. This will reflects the overreliance on conventional waste collection, treatment and disposal is not sustainable solution and it is too costly with considering on other economical aspect.

The resource value of MSW cannot be realized unless separation of wastes is practised effectively at the source. Then, it is very difficult to change the long established habits & attitude of people. Therefore it is essential to presume on partially segregated/mixed waste from the source till the fundamental change in mindsets and attitudes toward as "waste" into
"resources." And Build a "resource management infrastructure".

There is an informal infrastructure in collection of recyclables in the country, with the contribution of the huge numbers of waste pickers, who perform such a crucial service to the Waste Sector. Meanwhile, they are not only protecting and empowering the poor, but are also proceeding towards meeting relevant development goals in the country. Providing of a better occupational environment, social recognizant and insurance through formalising the informal sector workers/waste pikers to the formal sector via raising the living standards. Then it can contribute in a meaningful way for an environmentally sound and socially acceptable business.

Affordability to the "resource management infrastructure" we can predict US$ (15 to 22)/ day income from a one metric ton of MSW through the Material Recover Facility (MRF) only from the Mix-Waste/Unsegregated Waste. Further there is a tipping charge of approximately US$ 4/Mt for MSW. Therefore with this present scenario income of US$ (1926) /Mt/day income can be expected without carbon credits. Besides the income will be increases with CDM and with the total quality management.

Further to that through the global perspective introducing of policy instruments such as "volume based fees" for solid waste collection could lead to reduction of MSW generation. This tool was succussed in Korea which to a
21.5% reduction of MSW generation from 1994 to 2009. In addition to that, application of the Cleaner Development Mechanism (CDM) with the certified emission reduction (CERs) and dominance in carbon trading to the waste projects can earn economical value with selling carbon credits to developed-country clients. Hence, we can predict a better solution for the financial burden in the waste management sector and step forward to the sustainability.

Through a MRF, resource recovery has become a major factor that determines the competitiveness of firms and that excel in resource recovery could take advantages of win-win solutions to meet international obligations on climate change and Improved resource recovery could also lessen potential pressures and avoid root causes of social conflicts that could arise from resource competition.

In the planning stage there are gaps in Local, institutional and stakeholder levels that will lead to ineffective. Solid waste management in Sri Lanka is struggling to handle the MSW produced in Local jurisdictions and lack of intergraded & up to date dataset. Therefore it is the high time to strengthen institutional capacities, skill development and awarenessraising with coordinate information and research, or to compile results with an intergraded manner and formulating a Central Organization for the whole country. Further Local Authorities should not stick with everything by themselves, It is key to success is to do what they are good at, and collaborate with other sectors in the society, such as private public partnership. Such efforts by adopting ISWM and 3Rs with disposal being just the last resort or least preferred option as well as set policy directions aiming for resource efficient, recycle-based society will help Local Authorities to reduce the financial burden on Local authorities for waste management, as well as reduce the pressure on landfill requirements.

9.0 Conclusions

Municipal solid waste (MSW) is a serious environmental & socioeconomic issue in Sri Lanka. The rapid development, urbanization, migration and population growth will further pressing these issues. To way-forward to the transition to more sustainable waste management in Sri Lanka, It is better to build a "resource management infrastructure" with the fundamental change of mindsets and attitudes toward "waste" into "resources" and tap the resource value of waste. With the present condition in view of the long-term upward trend and volatility of prices material recoveries, many profitable new business opportunities are available in environmentally responsible recycling and waste disposal.

Therefore suggested that the importance of ISWM by maintaining a sustainable composite mechanism through locally – available materials and expertise, with evidence based approach planning and strategy by eliminating the potential risks to provide a clean, healthy pleasant living environment and resource management culture for current and future generations of Sri Lanka.

Acknowledgement

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